Sci

Index Issue

SCIENCE

26 December 1958

Volume 128, Number 333

6 JAN 6 1959
Cont. Copy

Editorial Thar's Gold in Them Bills 1597

Articles International Geophysical Year: *H. Odishaw* 1599

The first of a two-part summary of IGY activities covers studies of the sun and upper atmosphere.

The Industry of Discovery: *S. H. Slichter* 1610

The part of research that is pursued for profit contributes to the growth and stability of the economy.

News of Science Young Research Workers Sought for Washington Area Laboratories; other events .. 1614

Book Reviews R. Jungk's *Brighter than a Thousand Suns,* reviewed by *E. U. Condon*; other reviews 1619

Reports X-ray Visualization and Analysis of Multicomponent Subjects: *R. S. Mackay* 1622

Geochemical Scavenging of Strontium: *C. Frondel* 1623

Rate of Swelling of Collagen: *H. R. Elden* 1624

Measurement of Precipitin Reactions in the Millimicrogram Protein-Nitrogen Range: *D. Glick* et al. 1625

Hypothalamic Lesions and Sexual Behavior in the Female Rat: *T. Law* and *W. Meagher* 1626

Departments Chicago Academy of Sciences; Forthcoming Events; Equipment 1628

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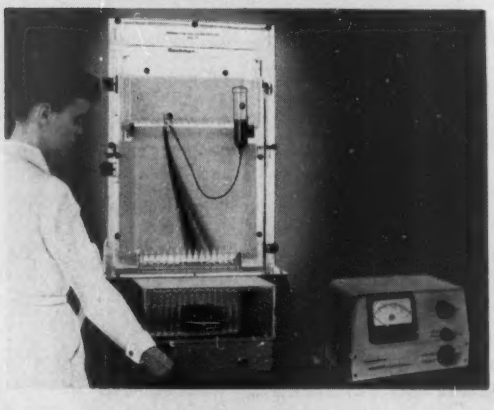

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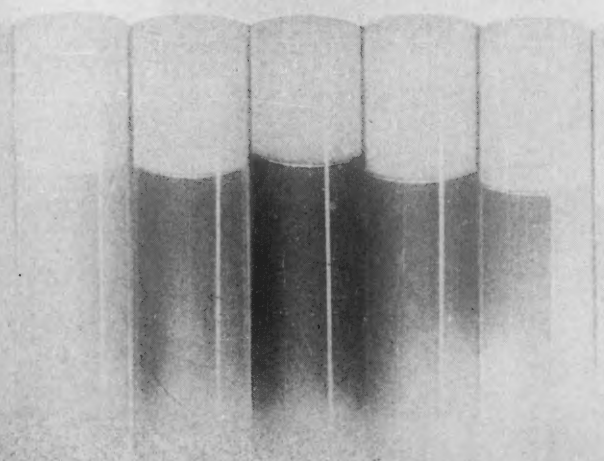

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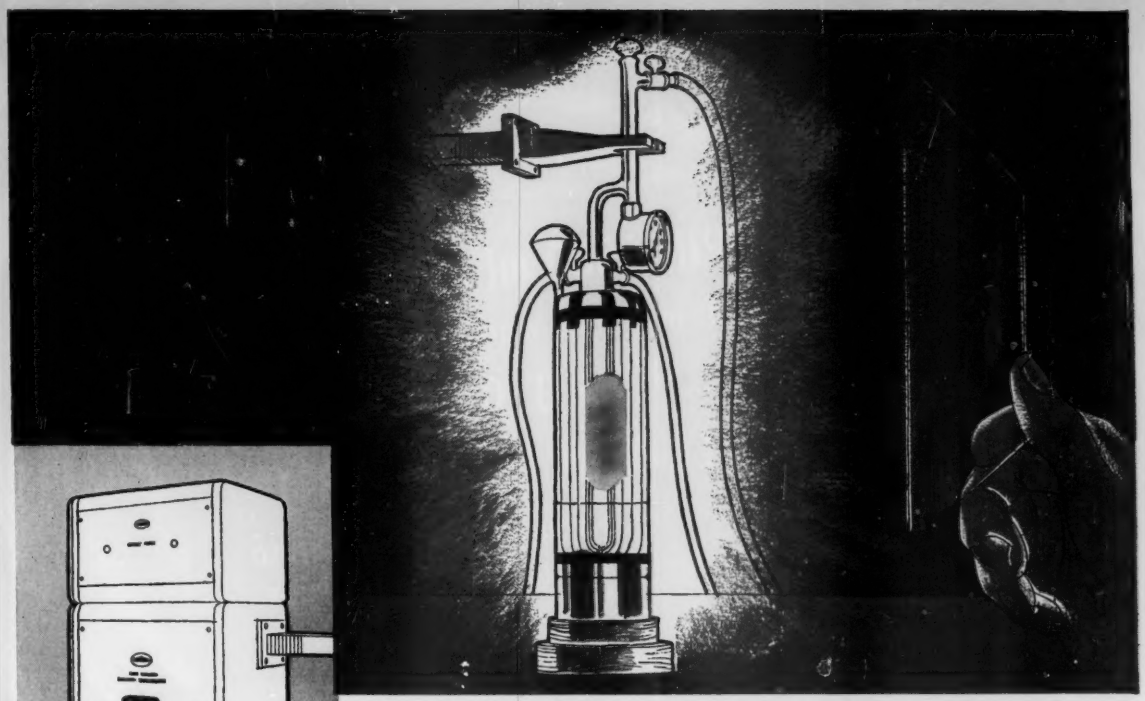

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Thar's Gold in Them Bills

When a citizen has been wronged or thinks that he has been wronged by the Government, he may not, in certain cases, resort to the courts for redress; he must instead appeal to Congress, which may pass a bill authorizing the Treasury to pay a specified amount or which may refer the matter to the Court of Claims for determination of the facts and a recommendation about what damages, if any, should be allowed to the plaintiff.

A case in point—and it is one in which we have had a continuing interest because of the way it pits scientific evidence against commercial interests—is that of the battery additive AD-X2. This case originated when the Federal Trade Commission and the Post Office Department asked the National Bureau of Standards to test the additive in 1952. The Bureau reported that AD-X2 had "no beneficial effect on the properties or performances of batteries," and the Post Office promptly barred the use of the mails for the promotion of the product. This order was suspended a few days later at the request of Senator Thye, chairman of the Senate Small Business Committee; on 24 March 1953, the Assistant Secretary of Commerce asked for the resignation of Allen V. Astin, director of the Bureau of Standards; Astin's resignation was accepted on 31 March. Thanks to vigorous reaction by scientists and the press, Secretary of Commerce Weeks reversed the decision and on 17 April asked Astin to serve till late summer or early fall; on 21 August he announced that Astin would be kept on as permanent director of the Bureau.

Despite the fact that the Bureau's findings were approved by a committee of the National Academy of Sciences that was especially appointed to appraise them, the Federal Trade Commission, acting on the basis of the testimony of users, dismissed the charges of false advertising against the manufacturer of AD-X2, Pioneers, Inc., of Oakland, California.

This put the company back in business but left it with a grievance. Accordingly, Representative John J. Allen, Jr., of California, introduced a bill (H.R. 3875) "for the relief of Pioneers, Incorporated, and Jess M. Ritchie, individually." The bill left the amount of damages unspecified, but by virtue of a resolution introduced by Allen (H. Res. 167) it was referred to the Court of Claims with the request that the court should make "such findings of fact and conclusions thereon as shall be sufficient to inform the Congress of the nature and character of the demand . . . and the amount, if any, legally or equitably due from the United States to the claimant."

The petition of Pioneers, Inc., to the Court of Claims is directed against the Department of Commerce and the Bureau of Standards and asks compensation for losses sustained in the amount of $2,369,064.52. The Government will respond to the petition on or before 24 January 1958. It is probable that the court will hold hearings and that a good deal of familiar ground will be reworked.

Meanwhile, any observer of the political scene may ponder the following facts, which are not in dispute: Representative Allen, who introduced the bill and the resolution, was defeated when he ran for reelection last month; this month President Eisenhower announced his intention of appointing Allen to the post of Undersecretary of Commerce early next year. If the appointment is confirmed, Allen will doubtless follow the progress of the AD-X2 case with especial interest, for he will be in a sense in the unusual position of being simultaneously plaintiff and defendant.—G.DuS.

METALLURGISTS • PHYSICAL CHEMISTS • SOLID STATE PHYSICISTS • CERAMISTS

ARE YOU OVERLOOKING SOME OF THE MOST CRITICAL CHALLENGES IN THE MATERIALS FIELD?

Listen in on this interview with Dr. A. E. Focke, Manager Materials Development at General Electric's Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio

Q. Dr. Focke, I have heard it said that the Aircraft Nuclear Propulsion Program adds a new dimension to materials technology. Do you agree?

A. Strictly speaking, Mr. Walsh, reactor development for any application may be said to do this, since materials must be selected for their nuclear as well as their physical properties.

For some applications we look for high neutron absorption cross sections; for others, low capture cross sections.

For example, the material selected for the *moderator* must be capable of slowing down the neutrons produced by fission to thermal energy, about 1/40 ev from their original energy of several million ev with a minimum loss of neutrons by parasitic capture. *Control rods* on the other hand, must have high capture cross section for neutrons.

In practically all material applications for the nuclear power plant for aircraft which we are developing here, however, we have a high temperature problem of dimensions unique in materials technology.

Q. Why is that, Dr. Focke? Aren't these problems similar to those already solved for marine nuclear propulsion?

A. In the ANP program weight and size are severely limiting factors. Here we are dealing with a small, high density reactor a small fraction of the size and weight of the submarine reactor. To jam high energy into small volume requires the development of high temperatures. Generally the higher the reactor exit-air temperature, the better the overall performance of the power plant.

The crux of the problem here is the fact that common materials desired for some parts of the reactor for nuclear considerations, cannot operate at the maximum temperature of the over-all system.

These charts, prepared for a recent paper will give you a better conception of the materials problem. Fig. 1 summarizes the general requirements. Figs. 2, 3 and 4 review a few of the basic physical properties of each of 11 metals selected for discussion.

Q. Can a materials man work effectively at ANP without previous training in nucleonics?

A. Certainly. All the orthodox skills of the metallurgist, ceramist or chemical engineer are called into play here. The Aircraft Nuclear Propulsion Department will provide necessary training and information in nucleonics.

Q. What you've just told me, Dr. Focke, I certainly can discern the challenge to the materials man that you have here. I suppose you are working with alloys of some of the more exotic metals so much discussed in the latest technical literature?

A. Security limitations forbid my naming specific materials on which we are concentrating our investigations at this time. We have, however, made considerable progress, though a great deal of work remains to be done before our first high performance nuclear power aircraft makes its maiden flight.

One of our principal problems is to be sure we have people with the required technical competence and specific abilities to function effectively.

Component	High Strength At High Temp.	Ability to Resist Oxidation	Neutron Absorption Cross Section	Density	Special Requirements
Fuel Elements	x	x	Low	--	Compatibility with fuel.
Moderator	x	x	Low	Low	Ability to slow neutrons to thermal effectively.
Control	x	x	High	--	
Shield					
a. Gamma	x	x	--	High(1)	(1) Ability to attenuate γ.
b. Neutron	x	x	High(2)	Low	(2) Ability to absorb without producing γ.

FIG. 1

Some characteristics of 11 metals in relation to possible application in Nuclear Power Plant for Aircraft—prepared by Dr. A. E. Focke, Manager, Materials Development.

Thermal Neutron Absorption Cross Section in Barns		Melting Point-°F	
1. Hf	105.0	1. W	6116
2. Re	84.0	2. Re	5756
3. Ta	21.3	3. Ta	5426
4. W	19.2	4. Mo	4752
5. U	7.68	5. Cb	4474
6. Th	7.4	6. Hf	4032
7. Ti	5.6	7. V	3452
8. V	5.1	8. Zr	3375
9. Mo	2.5	9. Th	3308
10. Cb	1.1	10. Ti	3020
11. Zr	0.18	11. U	2071

FIG. 2 FIG. 3

Crystal Structure		Allotropic Transformation
1. Re	h.c.p.	NONE (known)
2. Hf	h.c.p.	b.c.c. 3020°F
3. Ti	h.c.p.	b.c.c. 1620°F
4. Zr	h.c.p.	b.c.c. 1584°F
5. Th	f.c.c.	b.c.c. 2426°F
6. W	b.c.c.	NONE
7. Ta	b.c.c.	NONE (known)
8. Mo	b.c.c.	NONE
9. Cb	b.c.c.	NONE
10. V	b.c.c.	NONE
11. U	ortho	tetra 1220°F; b.c.c. 1427°F

FIG. 4

Metallurgists, ceramists, physical chemists, solid state physicists with background in hi-temperature materials are invited to inquire about professional opportunities in these areas. Nuclear experience, while desirable, is not essential.

Write in confidence including salary requirements to: Mr. P. W. Christos, Professional & Technical Personnel—Division 63-WP

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A FEW OPENINGS IN OTHER AREAS OF THE PROGRAM FOR: NUCLEAR ENGINEERS • THERMODYNAMICISTS • MATHEMATICIANS

26 December 1958, Volume 128, Number 3339 SCIENCE

International Geophysical Year

The first of a two-part summary of IGY activities covers studies of the sun and upper atmosphere.

Hugh Odishaw

An earlier report outlined some of the activities of the IGY, especially as reflected in our own program, during the first months of the endeavor (*1*). Here an attempt will be made to narrate, on behalf of the IGY scientific community and based upon their reports to the National Academy of Sciences, some of the events as the IGY reaches its formal close on 31 December 1958 (*2*). Just as the earlier report could be only suggestive, this too can but touch upon a few of the happenings, largely within the U.S. program, but perhaps some feeling for the whole effort can be conveyed. Some of the work described here has been reported in the scientific literature, and various papers are in press or preparation. IGY bibliographies are being prepared by several agencies; they now exist in interim and draft form (*3*, *4*).

The magnitude of the effort was appreciable, and some statistics show this clearly. For example, Table 1 presents the number of principal stations in each activity, grouped by latitude zone and indicating the degree of geographical coverage that was attained. The total number of stations is incorrect because there is duplication where projects in two or more fields were housed in a single structure. The correct total, in the sense of the table and based on the CSAGI geographical distribution list of 27 June 1958, turns out to be 2461, but this too fails to present the whole picture: First, from a scientific point of view, the uncorrected table number of some 3500 stations is more truly representative of the total station activity. Second, some stations were added after the compilation of the list. Third, many temporary stations, all surface meteorological stations (about 2500), and perhaps 1000 auroral and satellite volunteer observation stations and sites have been excluded. The best that one can do, therefore, is to say that some 4000 principal scientific stations and several thousand contemporary and volunteer sites or stations were active.

Similar difficulties beset one in establishing how many individuals took part in the IGY or in estimating the costs of the over-all effort. Both of these difficulties stem in part from the variety of ways in which the various national committees funded their programs and from the extensive voluntary contributions made by public and private institutions. It is probable that some 20,000 to 30,000 scientists, engineers, and technicians were engaged in the effort, supplemented by a somewhat comparable number of volunteer observers.

The story that can now be told encompasses three aspects of the IGY: (i) the discoveries and specific results that can readily be interpreted; (ii) the synoptic effort, which yielded vast quantities of data; (iii) the direct impact upon coming geophysical programs. In this article, the sampling is concerned with the upper atmosphere and the sun. Part II will similarly survey the heat and water regimen, the earth sciences, the synoptic data aspects, and post-IGY developments, particularly those for 1959.

Studies of solar activity, aurora and airglow, cosmic rays, geomagnetism, and the ionosphere provided a wealth of data and many concrete, striking findings. The simultaneity of the observations and measurements, which the IGY emphasized, proved invaluable, while the availability of rocket and satellite vehicles remarkably augmented the information secured from ground stations and observatories and balloons and aircraft (see Figs. 1 and 2).

Solar Activity

Studies of the sun during the IGY may be divided into two groups, regular surveys and special researches, even though the former also has important research values.

More than 100 patrols—visual, optical, photographic, photometric, and radio—kept the sun under constant watch at every minute throughout the IGY period. This unprecedented watch on the sun yielded ample returns. It permitted the detection of solar flares, and such information was channeled by solar observatories to the IGY World Warning Agency in the United States, where daily analyses were made of the likelihood of a solar disturbance with ensuing terrestrial effects. Between 28 June 1957 and 30 November 1958 these analyses led to the calling of 38 "alerts"—messages radioed throughout the world calling attention to the probability of the declaration of a Special World Interval. These intervals, of which there were 20 between 28 June 1957 and 30 November 1958, permitted scientists everywhere to intensify their measurements during the great periods when high atmospheric disturbances followed in the wake of major solar flares.

Chosen because it coincided with the current maximum of the sunspot cycle,

Dr. Odishaw is executive director of the U.S. National Committee for the International Geophysical Year, National Academy of Sciences, Washington, D.C.

the IGY period witnessed the greatest level of solar activity in history: the Zurich Observatory, international clearing house for sunspot statistics, reported that 1957 had the highest yearly mean in relative sunspot numbers since 1778, while the level of activity during 1958 seems to have been somewhat lower. The maximum of the present cycle fell almost in the middle of the IGY period.

In the patrol program photographs of the sun were taken by many observatories—every minute and even more often—in the light of hydrogen and calcium lines. These photographs, in effect a time-lapse study of the solar disk, provide, together with other related observations, the most detailed record of the sun in history. Taken during the greatest cycle of sunspot activity ever observed, this corpus affords a great body of information for astronomical analysis.

One of the new devices used in the solar program was the K-coronameter, used to measure the brightness of electron-scattered light in the K- or electron corona of the sun. Much fainter than the emission corona of ordinary atomic transitions, the K-corona requires unusually clear skies. Some fifty such days at the High Altitude Observatory Climax station yielded previously unobserved details of the sun. W. O. Roberts reports that variations of the depths of the layers of the corona, where temperatures of 1.5×10^{6}°K, prevail and where appreciable solar radio noise originates, were studied.

At the High Altitude Observatory, a line profile spectrograph has yielded some interesting data. D. E. Billings has completed a pilot analytical study which shows promising preliminary results on analyses of line spectra in H-alpha of about 50 small flares. Billings has produced a detailed graph of the optical depths of the flare gases as a function of wavelength, from the center of the spectrum line into its wings. Observatory scientists believe that if it proves possible to extend this kind of analysis to other flares, the results will be of the highest importance in flare physics. Such work will have a crucial bearing on problems of flare emission at wavelengths beyond the visible and on studies of the effects of flares in the earth's upper atmosphere and on geomagnetic disturbances.

H. Smith and his associates at Sacramento Peak Observatory report that a detailed discussion of the physics of the flare of 18 September 1957 is in process. The flare was photographed with the Sacramento Peak universal solar spectrograph covering 3878 to 7200 angstroms,

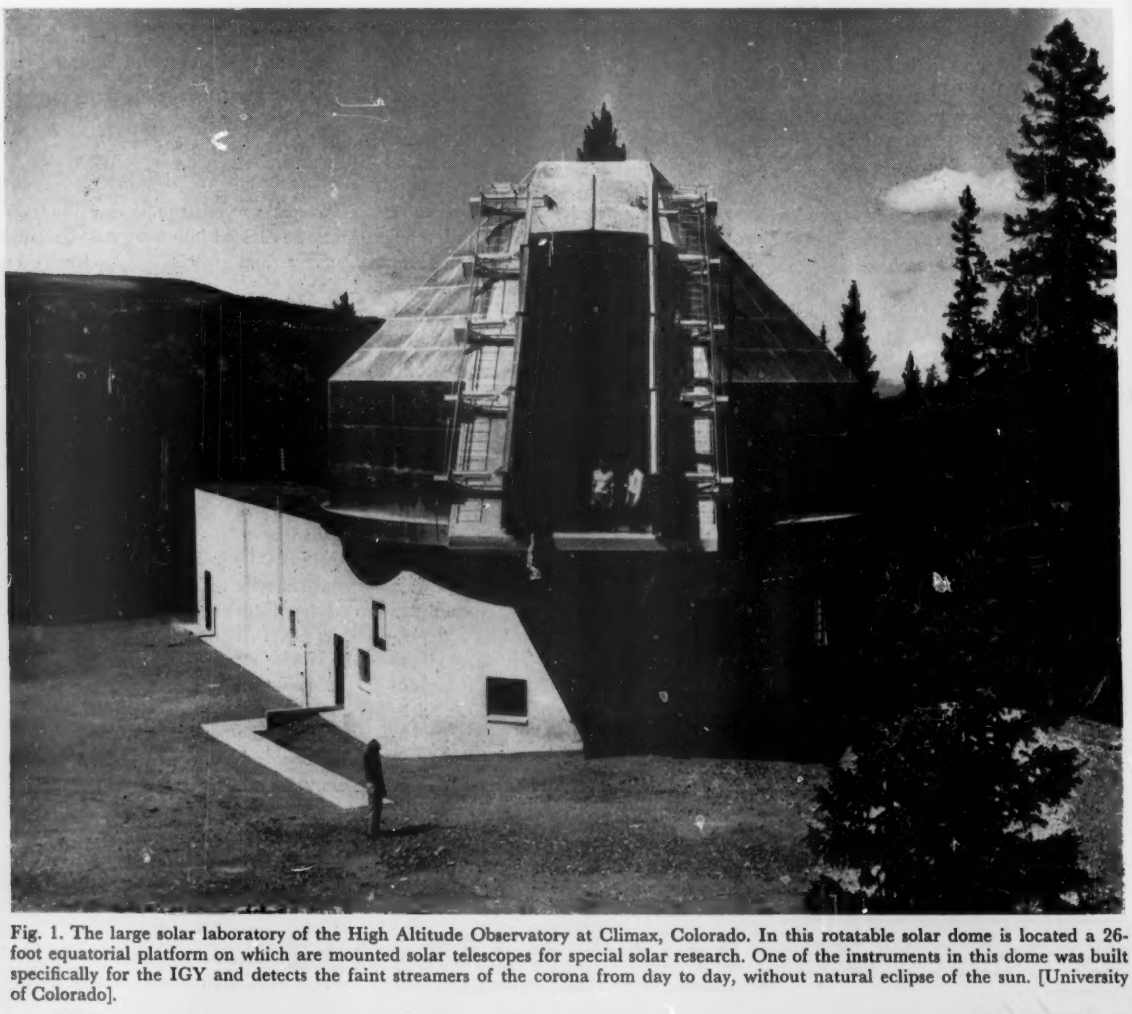

Fig. 1. The large solar laboratory of the High Altitude Observatory at Climax, Colorado. In this rotatable solar dome is located a 26-foot equatorial platform on which are mounted solar telescopes for special solar research. One of the instruments in this dome was built specifically for the IGY and detects the faint streamers of the corona from day to day, without natural eclipse of the sun. [University of Colorado].

Table 1. General list of principal IGY stations (from CSAGI Geographical Distribution List, 27 June 1958).

	World days and communications	Meteorology	Geomagnetism	Aurora and airglow	Ionosphere	Solar activity	Cosmic rays	Longitudes and Latitudes	Glaciology	Oceanography	Rockets and satellites	Seismology	Gravimetry	Nuclear radiation	Totals
Arctic ($\Phi > 60°N$ or $\phi > 60°N$)	4	158	46	77	51	2	19	2	31	16	7	23	13	43	492
Subauroral North ($60°N > \Phi > 45°N$ except if $\phi > 60°N$)	18	358	56	42	66	63	38	37	12	46	21	83	37	160	1037
Minauroral North ($45°N > \Phi > 20°N$)	20	270	46	19	54	39	34	23	10	74	21	86	40	90	826
Equatorial North ($20°N > \Phi > 0°$)	10	89	18	4	33	9	8	4	—	50	5	35	9	30	304
Equatorial South ($20°S > \Phi > 0°$)	9	96	20	5	28	6	9	4	6	29	8	39	8	26	293
Minauroral South ($45°S > \Phi > 20°S$)	6	100	12	3	23	7	7	8	5	57	8	43	18	41	338
Subauroral South ($60°S > \Phi > 45°S$ except if $\phi > 60°S$)	1	13	6	8	11	1	7	1	1	17	1	8	6	9	90
Antarctic ($\Phi > 60°S$ or $\phi > 60°S$)	1	34	19	23	18	—	6	—	38	12	5	15	19	1	191
	69	1118	223	181	284	127	128	79	103	301	76	332	150	400	3571

with dispersion of 2 angstroms per millimeter and exposure of 3 seconds. The analysis of the observation showed a marked red shift, indicating a downward motion of material toward the solar disk. Twenty different ions were detected in the flare spectrum, and excellent profiles were obtained for the heavier lines.

Measurements of the sun's surface magnetic field were made at Mount Wilson Observatory, revealing very high fields associated with some sunspots—as much as 8000 times the earth's field at the equator. H. D. Babcock and W. C. Livingston reported that the south magnetic pole of the sun reversed its polarity and that the north pole intensity decreased: these events have a time-lag of some 3 years with respect to minimum sunspot count. Mount Wilson scientists believe that variations of the sun's field probably reflect large-scale patterns of circulation related to the 22-year solar magnetic cycle, and they seem to be related to various solar-terrestrial phenomena.

Aurora

The IGY period was remarkably rich in auroral observations. C. W. Gartlein (Cornell University), responsible for the visual observation program in the United States, reports that in the first six months of the IGY there were 103 nights on which auroras were seen in the United States. In the first six months of 1958 there were over 110 nights on which auroras were seen. In March 1958 auroras were seen on every night except that of the 31st.

Auroral activity was also monitored by all-sky cameras, radar, and absorption equipment (see Fig. 3). The absorption program has turned up some interesting information that possibly bears on emission of soft cosmic rays from the sun during flares. H. Leinbach and G. Reid (Geophysical Institute, University of Alaska) report that absorption records from Thule and two locations in Alaska, following a solar flare, give strong suggestion of solar cosmic ray emission at low energies. The absorption equipment, a relatively simple and reliable noise receiver, promises to play an important role in the study of the relationships of auroral, ionospheric, and solar phenomena.

A new twilight phenomenon, the presence of a line at wavelength approximately 6700 angstroms, has been discovered in spectra taken in Antarctica during the last few months of 1958. First reported by the joint New Zealand-U.S. station at Cape Hallett on 5 August 1958, the radiation has been observed at all the U.S. antarctic stations with the exception of Little America, and by the New Zealand station at Invercargill. This radiation has been attributed to lithium in the high atmosphere, a constituent not previously known to be present there. The twilight display is evidently analagous to the familiar sodium twilight radiation often observed. A plain inference is that these new manifestations could be related to nuclear tests carried out during the same period as the IGY program.

At a recent meeting of the USNC-IGY Technical Panel on Cosmic Rays there was discussion of the suggestion by E. P. Ney and P. J. Kellogg of the University of Minnesota that a large nuclear explosion might result in some permanent perturbation of the earth's external magnetic field. Although it was recognized that the energy contained in the external field is a small fraction of that in the internal field of the earth, Ney and Kellogg pointed out that the total energy contained in the external field is of the order of that in a large nuclear explosion, which suggests the possibility of appreciable effects. No a priori reason was advanced why this could not take place. The temporary effects would disturb the trapping conditions for the Van Allen particles and, allowing their release, could produce an aurora. [In this connection it is interesting to note that A. L. Cullington of New Zealand has recently reported the observation, at Apia on 1 August 1958, of a man-made or artificial aurora (*5*).]

The interdisciplinary value of the simultaneously conducted IGY studies, often already indicated, is perhaps most strikingly suggested in the report of scientists at the University of Minnesota (J. R. Winckler, L. Peterson, R. Hoffman, and R. Arnoldy) on the great auroral storm of 10–11 February 1958, summarized as follows:

Balloon-borne instruments at Minneapolis detected two groups of strong x-ray bursts during the storm. These coincided with two large magnetic bays, with strong absorption of radio noise, and with the passage across the zenith of a very large amount of auroral luminosity. A cosmic ray decrease also accompanied the storm. The University of Minnesota workers believe that these terrestrial disturbances were associated with the earth's entry into a large cloud of solar gases that may have originated in a solar flare occurring about a day earlier.

The aurora observed in North America during this storm was one of the most spectacular in recent years. It was reported as far south as Cuba. At Minneapolis, the aurora was seen by visual observers simultaneously with the sudden commencement of the magnetic disturbance, at 0126 U.T. on 11 February. The all-sky camera record from Hanover, N.H., shows its appearance a few minutes after the magnetic disturbance began. At Minneapolis, from 0130 to 0330 U.T., a very intense diffuse green arc

covered the sky from 20 degrees above the northern horizon to the zenith and from the eastern to the western horizon. The outstanding feature, however, was the red color, also very intense, which appeared in diffuse patches at high angles above the northern horizon and, at 0200 U.T., covered the northern sky from 15 to 30 degrees elevation as a diffuse arc.

The southern limit of arc forms reached a geomagnetic latitude of 46°N at 1000 U.T. on 11 February 1958. It is estimated that the aurora extended from a height of about 200 to 800 kilometers, and for a distance of about 9600 kilometers east-west and 400 kilometers north-south. In addition to a very high intensity of both the red and green spectral lines, other unusual features of the aurora were the diffuseness and extent of the luminescence and its persistence for long periods without major changes in form. Spectra taken in Alaska by scientists of the Geophysical Institute showed unusually strong development of infrequently noted emission lines. The outstanding solar event of the period preceding this aurora was a flare, reported by Honolulu Observatory as class 2 and by Sacramento Peak Observatory as 2^+; this flare started at 2108 U.T. on 9 February and ended at 2302 the same day, with its maximum phase at 2140. Nevertheless, since considerable solar activity was present for several days prior to the terrestrial storm, the solar-terrestrial relationship is not completely certain. Large radio-noise fluxes were reported by several stations during the flare.

Fig. 2. One of the solar radiometers at the Gunbarrel Hill field site of the Boulder Laboratories, National Bureau of Standards. The reflector is 25 feet in diameter and is mounted so as to follow the sun throughout the day. It is in continuous operation to monitor radio noise from the sun. [National Academy of Sciences]

The terrestrial effects of this storm began at 0126 U.T. on 11 February, according to the rapid-run magnetogram of Fredericksburg (Va.) Observatory. The horizontal component (H) of the earth's magnetic field immediately showed a bay of $+117\gamma$, followed by a disturbed period and a second sharp, positive bay of about 500γ, which appeared at 0159. This sudden increase in the horizontal component was accompanied by sharp drops of about 150γ in the vertical component (Z) and 30γ in the magnetic declination (D). It is assumed that these pulses represent the initial encounter of the solar gas cloud with the earth's dipole field or the sudden appearance of ionospheric current systems, or both.

Large earth currents were observed coincident with the horizontal-component peak at 0159. T. E. Talpey (Murray Hill, N.J.) has stated that the earth's potential at the western end of the North Atlantic Telephone Cable from Newfoundland to Scotland dropped from a maximum of about 2650 volts at 0202 U.T. on 11 February, through zero to a peak in the opposite direction at 0209. The current was driven from west to east through the cable and seemed to be an induction effect associated with the second magnetic peak.

The circuit loop of the earth current, if considered to lie in a vertical east-west plane, requires a return path through the sea *above* the cable. However, derivation of the potential in the water gives only about 15 volts around the circuit, compared with the measured maximum of 2650 volts.

Thus the earth current was apparently part of a system flowing in the earth's surface and associated with changes in the vertical component in an unexplained way. The current system seems to have been centered over the eastern United States.

A balloon launched at Minneapolis at 0445 U.T. on 11 February encountered the first detectable x-ray bursts at 0622, coincident with the major decrease in the first large magnetic bay of the second phase of the storm; these bursts continued until 0730. A second large period of bursts occurred at 0850, coincident with the second magnetic bay of this phase.

It is thought reasonable to assume that both the changes in conductivity of the

ionospheric E-layer, which produced the magnetic bays, and the observed x-rays had a common origin in electrons produced by the solar gas stream. Their energies would lie in the range from 40 to 100 kv or higher; most of their energy, however, would be lost in the atmosphere as ionization and as the visible auroral light. About 1/1000 of the energy would be radiated as bremsstrahlung x-rays, the higher-energy components of which are detected at balloon levels (about 100,000 feet).

Large absorption of cosmic radio noise at 18 megacycles per second at Boulder, Colo., was observed exactly coincident with the magnetic bays and the x-ray bursts. The records give evidence of a very widespread increase in ionospheric electron density extending north-south for at least 150 kilometers. The correspondence of data from Fredericksburg, Minneapolis, and Boulder (Fig. 4) shows that the major primary fluctuations were simultaneous over distances of thousands of kilometers.

The large changes in the horizontal component of the magnetic field, the strong cosmic-noise absorption, the auroral x-rays, and the general presence of the aurora itself are all consistent with a very intensified bombardment of the ionosphere by high-energy electrons between 0530–0700 and 0830–0930 U.T. on 11 February over central United States.

It is interesting to note that, on the basis of the auroral electron flux (6×10^6 electrons per square centimeter, per second) inferred from x-ray intensity and energy, the electron density at Boulder coincident with the 10–11 February aurora is computed to be 1.2×10^5 electrons per cubic centimeter. This is in reasonable agreement with the value of 1.4×10^5 electrons per cubic centimeter obtained through cosmic-noise absorption studies on the assumption that absorption during an auroral storm occurs mainly in the upper D-layer, at altitudes of 80 to 90 kilometers.

There is, however, a discrepancy between visual estimates which placed the lower limit of the auroral luminosity at 200 kilometers and any suggestion that soft x-rays in the form of bremsstrahlung produced at this level might be responsible for the D-layer electrons causing noise absorption. This arises because there is insufficient x-radiation produced as bremsstrahlung to account for the lower level ionization if the limit of luminosity marks the lowest level of penetration of the electrons or other primary ionizing agent.

Therefore, either the estimated height of 200 kilometers was too high and the lower border of the aurora was actually at the usual height of 75 to 100 kilometers, or electrons or other particles carried considerable energy downward, below the visual auroral border.

The storm was accompanied by a world-wide Forbush-type decrease in the intensity of galactic cosmic rays as demonstrated by recordings of two groups of ground-level neutron monitors: one in Europe and Africa, close to the longitude of Greenwich, except for a station at Hobart, Tasmania (longitude 145°E), and the other in the Western Hemisphere extending from Northern Canada to the Antarctic approximately along 90°W. All stations showed an initial drop at 0200 U.T. on 11 February of roughly the same amount, 4 to 6 percent. An interesting feature of this Forbush-type decrease, apparently reported for the first time, was a "precursor" drop in intensity that occurred closely coincident with the sudden commencement of the magnetic storm, at 0127 U.T.

High altitude soundings with a standard ion chamber and counter were taken before, during, and after the decrease. The total influx of cosmic-ray energy, obtained by integrating the ion chamber rates throughout the atmosphere, dropped 14.9 percent during the storm; by 16 February it had recovered to within 8.4 percent of the 8 February value.

All the phenomena described are consistent with the passage of the earth into a remarkably intense solar cloud, which may have originated in the solar flare beginning at 2108 U.T. on 9 February and ending at 2302 on 9 February.

If the cloud originated with the 2-hour

Fig. 3. Photograph taken just prior to removal of the protective plastic dome from the all-sky camera installation at Fritz Peak, Colorado, field station for the National Bureau of Standards, Boulder Laboratories. The camera, using an image from a hemispherical mirror, shown in the center, gives horizon-to-horizon sky coverage for the IGY aurora program. [National Academy of Sciences]

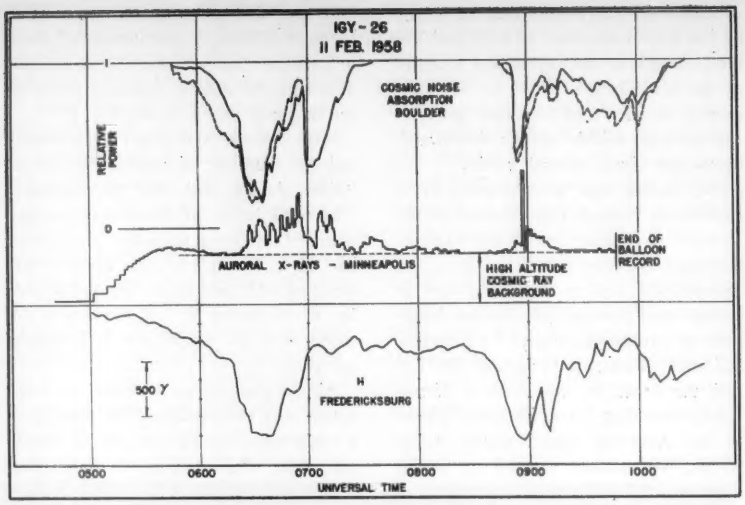

Fig. 4. Comparison of the horizontal field at Fredericksburg, auroral x-rays measured at Minneapolis, and cosmic noise absorption measured at Boulder. Two cases of intense ionospheric ionization apparently occurred, reaching maxima at approximately 0630 and 0900. The ionization was very widespread, as shown by this correlation and by all-sky camera photographs.

interval of the flare and required 24 hours to pass the earth, considerable velocity dispersion must have been present in the solar gas so that the slower solar particles could predominate later in the storm. The leading edge of the cloud must have been exceedingly well defined, and the cloud must also have contained considerable internal structure, as revealed by "spikes" in the first phase and by the two large bays accompanying the x-ray bursts later in the storm. These structural features persisted during the sun-earth passage despite the large velocity dispersion.

Although the modulation of galactic cosmic rays in this storm, while appreciable, was in no way exceptional when compared with other Forbush-type decreases, the storm was nevertheless unique with respect to the great intensity of the associated ionospheric phenomena; this may reasonably be attributed to an exceptionally high density of the solar gas enveloping the earth. The aurora of 10–11 February was one of the most intensely studied solar-terrestrial phenomena of the IGY.

Cosmic Rays

The scheduling of the IGY for a period of maximum solar activity was of particular value to cosmic ray research. Appreciable advances were made in our understanding of cosmic rays and their causes, effects, and interrelationships with other phenomena (see Fig. 5). A very interesting aspect was the relevance of cosmic rays to explorations of the geomagnetic field.

The beam of cosmic rays coming largely from the galaxy changed drastically between the last minimum of solar activity (1954) and the present maximum (1957–58). S. E. Forbush, studying μ-meson intensities, found that the results show an 11-year cycle of intensity variations which is roughly opposite in phase to that of sunspot numbers but lagging in phase by about 1 year. J. A. Simpson and his colleagues (University of Chicago) found a decrease of 25 percent in neutron intensity at Climax, Colorado, between 1954–55 and the early part of 1958, with a more than twofold decrease in this period for particles with energies of 1 Bev or greater. H. V. Neher (California Institute of Technology) found that ionization at Thule, measured aboard balloons at 93,500 feet, was only half that of 1954 and that the number of primary particles was diminished by a factor of 4. J. R. Winckler and L. Peterson (University of Minnesota) studied vertical particle flux using balloons at northern geomagnetic latitudes between 51.2 and 64.2 degrees: above 33,000 feet the flux decreased near sunspot maximum; the decrease becomes greater with increasing height and at both high latitudes and altitudes was down by nearly a factor of two. These experiments showed that, of the additional particles admitted at some 100,000 feet in 1955 between north geomagnetic latitudes 51.2 and 58.6 degrees, at most only one-sixth remained near sunspot maximum and that the relative latitude effect in this range was reduced from 40 to 10 percent or less.

During the past several years, it has become clear through the work of U.S. investigators that the intensity of the cosmic radiation reaching the earth undergoes large changes with time, and that these changes are associated with electromagnetic phenomena on the sun. Phenomena that produce large changes in the cosmic ray intensity at the earth have become the central problem of interest. Not only does their study add to an understanding of cosmic ray and solar effects, but analysis of these data is leading to knowledge of magnetic fields in interplanetary space and to explanation of many magnetic storm effects at the earth's surface.

In 1957, large decreases in cosmic-ray intensity during magnetic storms were unusually numerous. Several U.S. investigators have recorded large variations in daily mean neutron intensity for various intervals during the IGY. The sudden decrease in daily mean neutron intensity from 29 to 30 August 1957 was between 8 and 10 percent at IGY stations operated by the universities of California and Chicago and the Bartol Research Foundation (Pennsylvania). This is about 2.5 times the change in ionization at Huancayo.

M. A. Pomerantz (Bartol Research Foundation) reports that values of daily means of neutron intensity at Thule (20 August 1957 to 31 March 1958) correlate well with values obtained by D. C. Rose at Ottawa and Resolute, Canada. Using balloons on several days between 21 August and 18 September, Pomerantz also measured the vertical quadruple-coincidence rate under 7.5 centimeters of lead at altitudes above the 28-gram-per-square-centimeter pressure level (80,000 ft). These results show a decrease of about 20 percent near 1 September 1957 as compared with 20 August 1957.

Two experiments conducted in 1958 with balloon-borne pulsed ionization chambers revealed that the fluxes of both heavy nuclei and high energy protons did not change at the same time when a decrease of 23 percent in the total intensity was recorded as indicated above. Taking the results of other investigators into account, as well, Pomerantz concludes that the current general reduction in the primary cosmic ray intensity is a consequence of a change in the cutoff rigidity only. He points out that a sharp cutoff of protons unaccompanied by a

corresponding cutoff of heavy nuclei could be reconciled by ascribing the observed decrease in primary intensity to the action of a cutoff mechanism at the sun upon low energy cosmic rays of solar origin.

Twelve-hour neutron-intensity means at Chicago from 22 July to September 1957 reported by Peter Meyer (University of Chicago) showed a range of nearly 20 percent. Meyer has also conducted balloon flights in Canada on days when the neutron intensity at Chicago differed, from one to another of these days, by 12 percent. His purpose was to determine whether the change in proton and alpha-particle flux is different at these two locations. On the basis of these balloon flights conducted during 1957 and 1958, Meyer reported at a recent meeting of the American Physical Society in Chicago that in general the modulation mechanisms responsible for intensity variations in cosmic rays affect both alpha-particles and protons in the same manner so that the ratio of fluxes remains constant. However, the independent behavior of the alpha-particle flux, when compared with the proton flux, as observed on certain individual flights, if real, may occur only at certain times, and perhaps only following Forbush decreases.

Because cosmic rays are deflected by magnetic fields, they may be thought of as probes to reveal the distribution and configuration of the magnetic field in the regions surrounding the earth. Investigations to locate the magnetic equator for cosmic rays are being carried out through multiple crossings of the equatorial region by ships and aircraft. These studies by J. A. Simpson (University of Chicago) and M. A. Pomerantz (Bartol Research Foundation) were mentioned in the earlier report (*1*).

K. A. Anderson (State University of Iowa) has reported unusual balloon observations taken at an atmospheric depth of 10 grams per square centimeter at Churchill on 22 August 1958, in which ionizing radiation appeared beginning at 1525 UT in time association with a great solar noise storm. The response of three balloon-borne detectors was not consistent with x-rays, high-energy gamma rays, or with electrons as a principal cause, but did correspond to protons with a kinetic energy of 170 Mev. From one previous balloon flight made from Churchill in 1957 there was strong evidence for the appearance of protons in the 100-Mev energy region during a period of high solar activity, but no further confirmation was obtained until the occurrence of the more recent event. The time scale and certain of the details of the event bore a strong resemblance to an x-ray shower observed on 29–30 August 1957, which suggests that the protons in the present event and the electrons, presumed to have given rise to the x-rays in the earlier event, are affected by a common mechanism. It was definitely established that the radiation present during the 1958 event was not associated with visible auroras, for sky conditions were excellent for observations. There was little if any magnetic disturbance present at the time.

Geomagnetism

Some 200 magnetic observatories recorded magnetic-field vector components on a regular basis during the IGY. These data, calling for appreciable analysis, have as their principal value their utility in interdisciplinary studies, particularly in correlations of events involving solar, ionospheric, auroral, and cosmic ray effects. Studies of cosmic rays themselves proved most revealing in throwing light on the earth's magnetic field in space. Emphasis in the United States geomagnetic effort was also placed on rapid variations, close network studies, and the electrojet phenomenon.

To determine whether magnetic field variations other than the daily variation also show electrojet effects, four stations equipped with Askania variographs were established for the IGY on the west coast of Peru by S. E. Forbush (Carnegie Institution of Washington), in cooperation with the Instituto de Geofisico de Huancayo. The maximum daily variation of the horizontal component was found to occur within 1 degree of latitude of Huancayo (12°S). This is in accord with results from the 1949 survey. It is also confirmed by the fact that the daily variation of the vertical component of the earth's magnetic field, obtained dur-

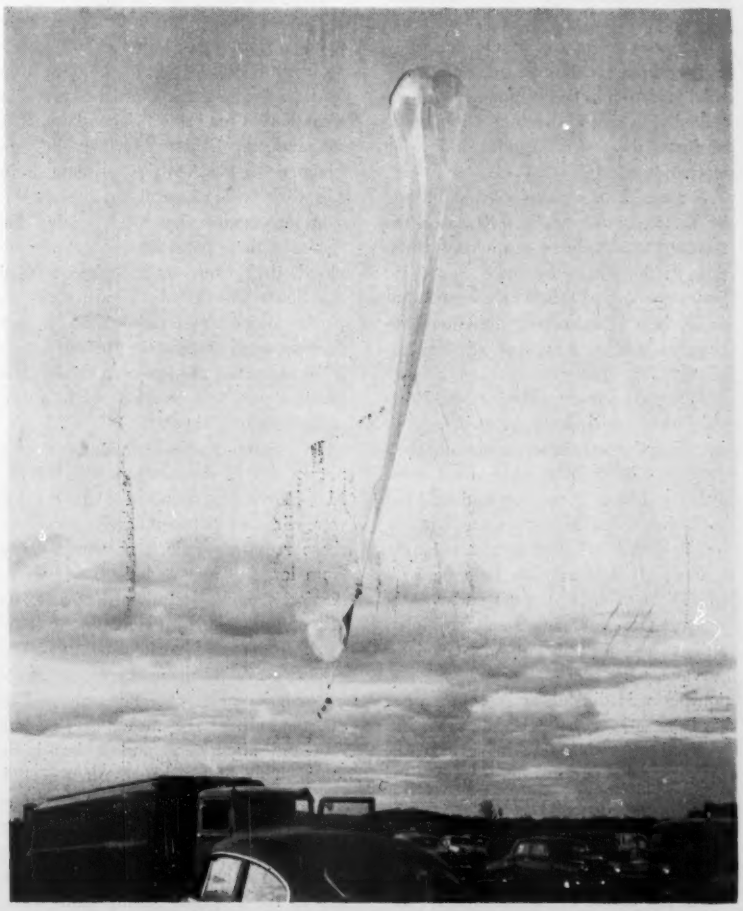

Fig. 5. Sky-hook balloon for the measurement of the variation in intensity in cosmic radiation over a period of time. [General Mills, Inc.]

ing the 1957 survey, changes sign at a latitude within 1 degree of Huancayo. A maximum daily variation in the vertical component occurred at about 16°S, and another maximum, with opposite sign, occurred near 8° or 9°S.

The north-south distance of 500 miles between these extremes provides a rough estimate of the width of the electrojet band. The difference with latitude of the daily variation of the vertical component indicates the importance of the return currents, which must flow westward, to the north and south of the eastward-flowing electrojet.

To estimate reliably the height and width of the electrojet, the electric current system of the electrojet field must first be derived. Before this derivation can be accomplished, the normal, quiet-day solar variation, estimated from data obtained at locations free from the influence of the electrojet, must be subtracted. Such height and width estimates have not yet been completed.

A preliminary examination of records indicates that many of the vertical-component fluctuations related to solar disturbances are greatest at the same latitudes where the largest quiet-day solar tidal variation in this component was observed. The sign of the fluctuations is opposite at these two latitudes, indicating electrojet effects.

A network of stations was established by E. Maple (Geophysics Research Directorate) to study geomagnetic fluctuations in the frequency range of 1 to 50 cycles per second. Maple has found that oscillations or micropulsations may appear, as well as signals of varying frequency. The latter often resemble the whistlers of audio frequency range. However, these subaudio "whistlers" sometimes first decrease in frequency and then increase, a behavior at odds with current whistler theory. Some correlations have been observed with magnetic activity, as well as occasional predisturbance signals.

The early data from the large network of IGY magnetic stations is under study and analysis by scientists at many institutions. The U.S. Coast and Geodetic Survey reports that operation of the stations, even in difficult and remote areas, has been satisfactory, and data are being received and reduced at the survey.

Ionospheric Physics

Because solar radiation largely determines the nature of the ionosphere, the character of the ionosphere close to the geographic poles during periods of prolonged solar absence was a subject of considerable interest. The South Pole Station provided a unique facility for this study by the National Bureau of Standards because there Antarctica offered a stable platform in contrast to the uncertainties of the shifting ice pack in the Arctic basin. In these regions the ionosphere is subjected to extended exposure to solar ionizing radiations during the long polar summer day, while it is screened for several months during the polar night. Scientists of NBS, Boulder Laboratories, reported that, from analysis of South Pole records at hand, the ionization reached a summer saturation, during the present solar activity, of about 4.5×10^5 electrons per cubic centimeter, which would support transpolar communications up to 22 megacycles per second. Throughout the winter polar night, it was found that the F-layer persists but that this usually rather uniform layer appeared to break up into cloud formations. A density of 2×10^5 electrons per cubic centimeter appears typical, sufficient to support transpolar communications up to 14 megacycles in the absence of ionospheric storms.

There is evidence from the data from both polar regions that the nonsolar variations in the F-layer depend upon the magnetic dip field rather than the geomagnetic field. Analyses of data from the world-wide chain of ionospheric stations are under way to determine the source of these polar ions: Do electronic clouds drift from sunlit regions toward the South Pole or do they manage to persist somehow throughout the winter? It is interesting that the ionization exhibits diurnal variation even though the sun is always at a constant height above or below the horizon.

Backscatter studies, conducted over a network of 13 stations supervised by A. M. Peterson (Stanford University), were directed at two types of problems: those requiring reflections continuously from large regions and those where reflection geometry requires the backscatter oblique-incidence technique. This work permitted the study of large-scale F-layer traveling disturbances and studies of ionospheric tilts. Peterson reports that the former were tracked over several thousand kilometers, and it has been found that the disturbances often extend several thousand kilometers in directions perpendicular to their paths, appearing as huge wave motions in the ionosphere.

Analysis of backscatter data shows that tilts in the F-region permit radio wave propagation over great distances without ground reflections. Tilts or horizontal gradients permit the propagation of radio waves over long distances by successive reflections from the curved F-layer until a particular tilt directs the energy to earth. Propagation over distances in excess of 6000 miles has been observed frequently.

During the IGY an extensive whistler program has been conducted by R. A. Helliwell (Stanford University) and M. G. Morgan (Dartmouth College) who are supervising two chains of stations running north and south along the coasts of North America, including cooperating stations in the Southern Hemisphere. Some of these stations were in operation prior to the beginning of the IGY, and it was at one of them (Hanover, N.H.) that correlation of whistlers and lightning flashes by direct visual and aural observations was definitely made just prior to the IGY. This has recently been reported in the literature with the conclusion that lightning flashes can generate whistlers although many of them do not.

The IGY whistler data show a marked dependence of the frequency of occurrence from place to place. Morgan finds that activity increases northward from none at all at Huancayo up to Hanover where a variety of very-low-frequency phenomena are recorded, and then diminishes nearly to the vanishing point at Frobisher Bay, North West Territories, and Thule, Greenland; high activity is noted from the Ellsworth Station in Antarctica. It is interesting that the Hanover Station has far more activity than does Seattle, Wash., although the two are at comparable geomagnetic latitudes.

Helliwell observes that high activity is also found at Unalaska, Alaska, and that in Alaska short whistlers are predominant whereas on the east coast of the United States short whistlers are a relative rarity. On one occasion the same whistler group was recorded at both Stanford and Seattle. However, the first component of the whistler observed at Stanford was extremely well defined and extended upward to 35 kilocycles per second, whereas no trace of the first component could be found at Seattle. Later traces in the group, on the other hand, were identical with those at Stanford. Nose whistlers (in which the frequencies both rise and fall simultaneously) have been observed for the first time at Stanford, and two have been found with nose frequencies of 10 and 16 kilocycles per second, which are low compared with the expected value of 45 kilocycles per second. A whistler has been recorded simultaneously at Stanford, Seattle, and

Anchorage, even though the distance between Anchorage and Stanford is about 3200 kilometers. The spectrograms show considerable similarity, but the dispersions of the separate components are not exactly the same at the three locations.

E. K. Smith (Central Radio Propagation Laboratory, National Bureau of Standards) has reported a peculiar signal enhancement noted during the last year on a very high frequency (49.84 megacycles per second) circuit operating between the Philippines and Okinawa which was set up to measure sporadic-E. The anomaly observed was a sudden enhancement of signal strength commencing about 2 hours after sunset and continuing until about midnight, being particularly strong during the autumnal equinox. This appears definitely to arise from F-region scatter. Studies by means of a pulse experiment carried out on the circuit seem to indicate F-region reflection from the path midpoint at 300 kilometers. The returned echo appears similar to those returned from extensive aurora curtains and may represent blobs of ionization oriented along the earth's magnetic field.

The reduction of vertical incidence ionospheric sounding records, or ionograms, to profiles of electron density as a function of true height, is being carried out at Pennsylvania State University by E. R. Schmerling, where an extension is used of the matrix method developed by Budden. Records from Washington, D.C., Panama, and Talara and Huancayo, Peru, have been reduced to individual profiles and read off to give the density at every 20 kilometers of true height. From examination of the 1957 data it has been discovered that the shape of the F-2 layer rarely corresponds to a parabola, an approximation sometimes used previously, and that there is a striking increase in electron density at night, particularly at Huancayo and Panama, where the layers rise at night and decrease in thickness.

Reduction of electron density profiles for many stations at scattered intervals (rather than more comprehensive coverage at a few stations) has been carried out at the National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colo., by the same method to determine the instantaneous horizontal distribution of electron density at a series of fixed heights over the United States. Applications include the interpretation of radio data from satellites or other sources within or beyond the ionosphere, the determination of ray paths for radio waves reflected at oblique incidence from the ionosphere, the study of regional anomalies, and the study of large traveling disturbances.

Other ionospheric scatter effects are being studied in a cooperative program under the supervision of K. L. Bowles and R. S. Cohen (Central Radio Propagation Laboratory, National Bureau of Standards), with the South American participating committees of Argentina, Brazil, Chile, Ecuador, and Peru. Six circuits, in which transmission is affected by ionospheric scatter of obliquely incident 50 megacycle waves, have been established by the Central Radio Propagation Laboratory to span the geomagnetic equator and provide east-west control data. The variability in daytime scattering along these paths has been found to correlate with the presence of equatorial sporadic-E. There is further correlation with intensity variations of the horizontal component of the earth's magnetic field. Since these are in turn associated with the equatorial electrojet, these propagation studies are helping to define the relation between equatorial sporadic-E ionization and the equatorial electrojet. On the other hand, nighttime scatter signal seems to be correlated with the

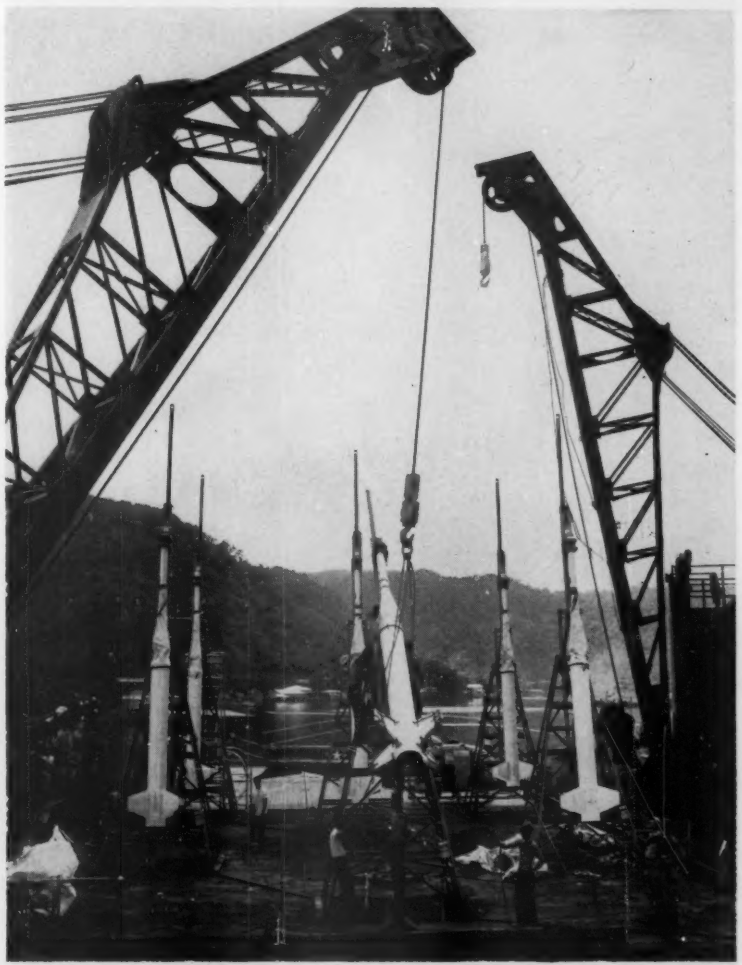

Fig. 6. A "forest" of six Nike-ASP rockets in the process of being erected on the deck of the Navy ship *U.S.S. Point Defiance*, anchored off the South Pacific island of Pukapuka in the Danger Islands. The rockets, launched under the auspices of the National Academy of Sciences' IGY program, were used to assist a team of Naval Research Laboratory and other IGY scientists in making radiation studies of the sun during the eclipse which occurred 12 October. In this first use of high-altitude rockets for astrophysical eclipse measurements, five were launched within a span of 40 minutes; two of these were in the air simultaneously during the total eclipse. Telemetering time averaged close to eight minutes per rocket. A sixth rocket was fired on 13 October, when a solar flare occurred following the eclipse. This rocket carried radiation measuring instruments to an altitude of 140 to 150 miles, exceeding all previous records for rockets launched from shipboard. [U.S. Navy]

presence of disturbed conditions in the F-region observed as equatorial spread. The knowledge that the nighttime transmission scattering probably occurs at 130- to 180-kilometer levels suggests that some of the spread-F and some of the long-path scatter signals at night are caused by the same ionospheric irregularities in the region from 130 to 180 kilometers in height.

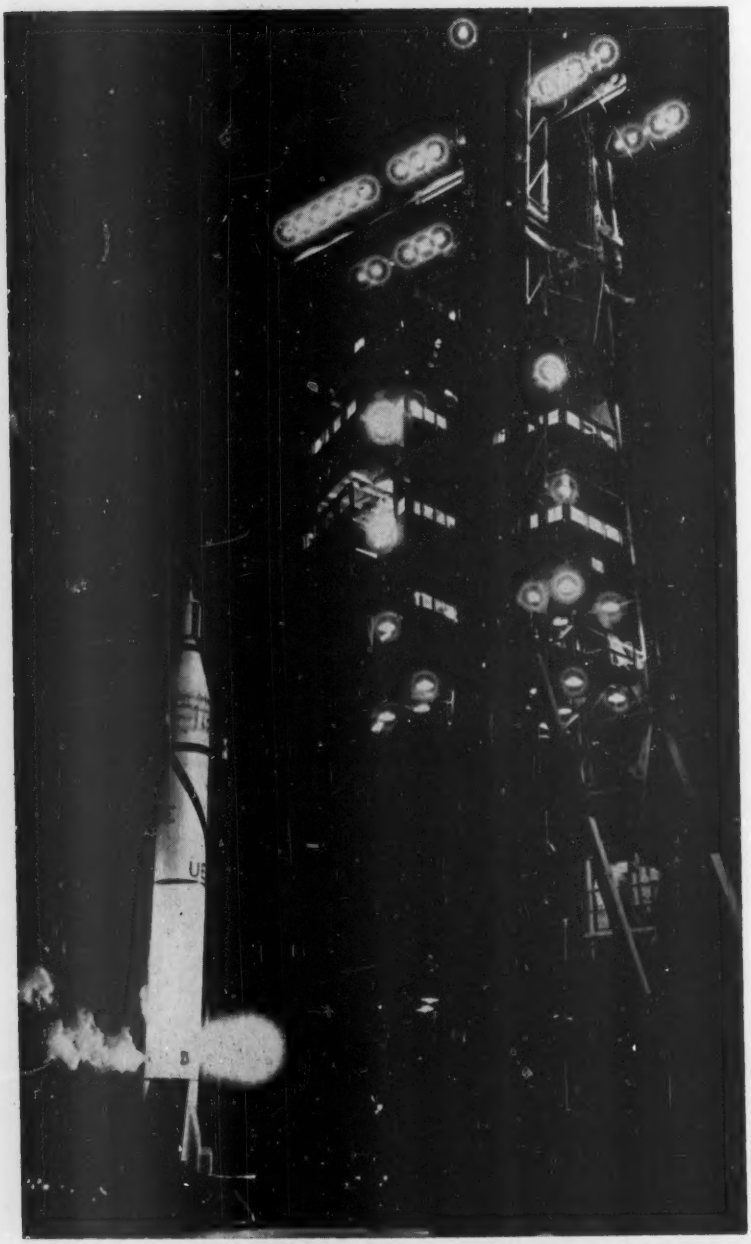

Fig. 7. The gantry crane, the lighted structure at right, is withdrawn in preparation for the launching of the Jupiter-C rocket (at left) at Cape Canaveral, Florida, at 10:48 P.M., EST, 31 Jan. 1958. This rocket placed the first U.S.-IGY earth satellite in orbit, seven minutes after firing. The satellite carried instrumentation to record data on cosmic rays, micrometeorites, and internal and skin temperatures, designed at the University of Iowa, the Air Force Cambridge Research Center, and the California Institute of Technology's Jet Propulsion Laboratory, respectively. The Jupiter-C rocket was jointly developed by the Army Ballistic Missile Agency and the California Institute of Technology's Jet Propulsion Laboratory and was launched by the Army Ballistic Missile Agency. [U.S. Army]

Rockets and Satellites

While rockets and satellites are only tools, albeit powerful ones, for *in situ* studies of phenomena in the high atmosphere and space, they have represented an important area of IGY activity and have stood in the international program as distinct efforts. Seven nations engaged in rocketry studies (Australia, Canada, France, Great Britain, Japan, the United States, and the U.S.S.R.) while two (U.S. and U.S.S.R.) launched satellites. More than 300 research sounding rockets of various types were fired, seven satellites were launched successfully, and one deep-space probe (Pioneer I) covered some one-third the distance toward the moon.

The quantity of data gathered by research sounding rockets was appreciable. Of great general interest were the studies of x-rays discovered by H. Friedman and his associates (Naval Research Laboratory) at times of solar flares in the lower, D-region of the ionosphere. It now appears this x-radiation creates the increased ionization which leads to radiocommunications blackouts at times of solar activity. X-rays, Friedman reports, increase with solar flare activity, while ultraviolet radiation does not, although measurements have not been made during the initial period of onset of flares. Moreover, during the eclipse of last October, Friedman employed rockets for the first time in such a study (see Fig. 6) and detected x-rays during total eclipse while ultraviolet radiation was completely absent, giving the first direct evidence that x-rays originate in the sun's corona, whereas ultraviolet radiation was absent during total eclipse. These experiments are significant not only because they add to our fundamental knowledge of the upper atmosphere and solar processes, but because the information sheds light on problems of the radio propagation.

Extremely important ambient pressure, temperature, wind and density data were also obtained from rocket firings by groups at the Naval Research Laboratory, Geophysics Research Directorate, University of Michigan, and the Army Signal Research and Development Laboratory. One of the significant findings revealed that the distribution of atmospheric pressure and temperature at high latitudes differs from that at lower latitudes. The density of the atmosphere is under strong solar influence. There appear to be latitude, seasonal, and diurnal effects. These effects appear only at high

altitudes above Fort Churchill, while none of these effects appear at lower latitudes.

A program at the State University of Iowa using balloon-borne rockets, called rockoons, had as its major purpose the measurement of total cosmic ray intensity over a wide range of geographic and geomagnetic latitudes during the present period of high solar activity. Special points of interest are (i) comparison of the intensity at upper atmosphere levels in high southern latitudes with intensity at high northern latitudes, and (ii) investigation of the location of the latitude "knee" in the Southern Hemisphere. Van Allen and his colleagues at Iowa report that flight data which have been read and reduced to date indicate that the total cosmic ray intensity at upper atmosphere levels in high southern latitudes is within 5 percent of that in high northern latitudes, and about 4.3 times as great as that near the equator. They also show that during the present period of high solar activity the latitude knee is found at a latitude lower than 50°S. Cosmic ray intensity at various altitudes is being systematically plotted against geomagnetic latitude.

Another aim of the Iowa research rocket program was precise measurement of the intensity of the terrestrial magnetic field to altitudes over 75 miles in the region of the equatorial electrojet. Van Allen obtained four satisfactory sets of data on magnetic intensity in the Line Islands at altitudes up to 84 miles, and flight data reduced during the IGY indicate new evidence for the existence of electric currents in the lower ionosphere. The full reduction of all four sets of flight data obtained in the Line Island area, when combined with the ground station measurements, is expected to yield illuminating information on the equatorial electrojet.

Several other Iowa experiments were conducted in the southern auroral zone. High-altitude measurements of the magnetic field were made for correlation with nearby antarctic observations. There were three successful magnetometer flights. Investigations were made here of the physical nature, intensity, and latitude distribution of the "soft radiation" associated with auroras. A flight at 70°48′S, 175°50′E was the only successful rocket flight of auroral instrumentation made in the zone. It encountered a high intensity of soft radiation resembling that studied extensively in the northern auroral zone during the rockoon expeditions from 1953 to 1957.

The most significant on-board satellite experiment to date now appears to be the work of Van Allen and his associates at the State University of Iowa, with radiation instrumentation on satellites 1958 alpha, gamma, and epsilon (commonly referred to as the Explorer satellites) (see Fig. 7). Satellite 1958 alpha led to the discovery of a zone of radiation in the high atmosphere. Van Allen reported that data from 1958 alpha and beta indicated that the radiation intensity of cosmic rays to 700 kilometers was as expected, but instrumental behavior beyond this range pointed to a great increase in intensity "totally inconsistent with cosmic ray expectations." The radiation was interpreted as corpuscular in nature.

More sophisticated instrumentation on 1958 epsilon provided added and better information. Van Allen and his colleagues believe it "is established that the great radiation belt around the earth consists of charged particles, temporarily trapped in the earth's magnetic field." They conjecture that the aurora is related to this trapped radiation and is caused by particle leakage from the belt. They suggest that solar plasma is the source of particles. These studies, in combination with other results of the IGY (the cosmic ray work, in particular), begin to relate a variety of atmospheric and spatial phenomena in an exciting and meaningful way, suggesting that major advances are in process of being made and formulated.

Many environmental studies were also carried out such as the temperatures of satellites (internal and skin) and exposure and behavior under micrometeorite bombardment. The solar batteries carried on 1958 beta have continued to operate since launching and have proved the feasibility of this source of power.

References and Notes

1. H. Odishaw, "International Geophysical Year: A report on the United States program," *Science* **127**, 115 (1958).
2. The preparation of this summary of IGY is based entirely upon reports and descriptions of projects supplied by the scientists and institutions engaged in the IGY research program. Many of them are mentioned in the text, although in this short summary it has not been possible to refer to all of the scientists who are producing contributions through their IGY programs or to describe all of the IGY accomplishments. The United States IGY program itself has only been made possible through the great contributions of time and effort of so many individual scientists and the participation and cooperation of public and private institutions. Particular acknowledgement should be made to members of the National Academy of Sciences' IGY staff who have assisted in the collection and preparation of the material contained in this article: Phillip W. Mange and Stanley Ruttenberg.
3. "An Interim Bibliography on the International Geophysical Year" (National Academy of Sciences, Washington, D.C., 1958, available from the Publications Office, at $1.00 per copy).
4. M. Nicolet, "Draft IGY Bibliography" (first and second issue) (CSAGI Secretariat General c/o Service du Rayonnement I.R.M., 3, Avenue Circulaire, Uccle, Belgium. Draft copies are not generally available; the completed bibliography will become available upon publication in the Annals of the IGY, published by the Pergamon Press).
5. A. L. Cullington, *Nature* **182**, 1365 (1958).

The Industry of Discovery

The part of research that is pursued for profit contributes to the growth and stability of the economy.

Sumner H. Slichter

The best way to indicate the significance of technological research for the growth and stability of the economy is to point out that technological research had developed sufficiently by 1937 to make Keynes' theory of employment obsolete on the day of its publication—in spite of invaluable concepts and tools of analysis contained in the work. The reason why his theory of employment itself was out of date on the day of its publication was that Keynes ignored completely the impact of technological research upon the economy. Hence, his theory of employment rested upon a theory of consumption and upon a theory of investment that were seriously in error. In addition, Keynes was led to the mistaken practical conclusion that economic progress inevitably creates a chronic deficiency of demand.

Today it is unthinkable that anyone should attempt to construct a theory of employment or a theory of growth without taking account of technological research. Within the last 30 years technological research has become a large activity that introduces fundamental changes into the operation of the economy. Measured in terms of the number of scientists and engineers devoting full time to technological research, this activity is more than five times as large as it was in 1930, and measured by the ratio of research expenditures to the gross national product, it is about 13 times as large. In 1956, the annual budget of technological research, according to estimates of the National Science Foundation, was about $9 billion a year. Research is growing right through the recession of early 1958 (as it grew steadily during the much deeper depression of the 1930's), and in 1958 research outlays will undoubtedly be well above $10 billion.

My remarks fall into four principal parts. In the first place, I wish to point out briefly some fundamental characteristics of technological research that give it far-reaching economic significance. In the second place, I wish to discuss more specifically the effect of technological research upon the capacity of the economy to grow—and particularly to point out some of the changes required by technological research in the theory of consumption and in the theory of investment. In the third place, I have a few observations to make concerning the relationship of technological research to economic stability. In the fourth place, I wish to discuss a few selected questions of general economic interest that are brought into being by technological research.

Characteristics of Technological Research

Technological research has three characteristics that give it far-reaching economic significance. The first of these characteristics is that it greatly increases the capacity of the economy to raise the demand for goods. It is obvious that technological research increases the capacity of the economy to raise productivity. Less obvious, and indeed generally overlooked, is the fact that research gives the economy the capacity to bring about planned increases in the demand for goods, both by creating new demands for consumption goods and by creating new investment opportunities. Naturally these capacities are fatal to the stagnation thesis expounded with such brilliant error by Keynes. I deal with this point more specifically below, where I discuss the effect of research on the theory of consumption and on the theory of investment.

A second characteristic that gives technological research far-reaching significance is the fact that much of it is a profitable activity as well as a useful activity. There are, of course, research areas of the greatest usefulness that cannot be investigated for profit and that must be handled either by nonprofit institutions, or by the government, or by private industry under government contract. Within the last half century, however, the fund of technological understanding has become sufficient so that many projects, particularly at the development level, can be pursued for gain. This means that many research programs can be determined by the economic calculus—by the balancing of expected gains against expected costs. The importance of this fact is that it draws into research far greater resources than would otherwise be available for it.

The part of technological research that can be carried on for profit should be regarded as an industry—the industry of discovery. Its product is knowledge. Slightly more than half of the research and development work now being conducted in private laboratories is financed by private funds for the purpose of making a profit. Thus, the National Science Foundation estimates that, in 1956, $3.4 billion of the $6.5-billion research budget of private laboratories was financed by industry's own funds, and $3.1 billion by the federal government.

A third significant characteristic of research is the fact that an increase in its output does not tend to reduce the marginal value of its product; on the contrary, it tends to increase the marginal value. Hence, the greater the output of research, the stronger tends to be the demand for still more output.

This peculiarity of research is a result of the fact that its output is knowledge. One may think of knowledge as consisting of a body of tested propositions. When two things are known, there is a possibility of seeing significant relationships between them which will yield practical applications. The larger the number of tested propositions, the more numerous are the cases in which the addition of a new tested proposition to old propositions will yield new useful applications and, in addition, will suggest hypotheses useful in adding still more

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tested propositions to the body of knowledge. Thus, the greater the body of existing knowledge, the greater is likely to be the value of the new discoveries.

All of this is particularly important for that part of research that is pursued for profit—the industry of discovery. Unlike other industries, the industry of discovery produces against a rising schedule of marginal utility, not a diminishing schedule.

Demand for Consumer Goods

The most important effects of technological research upon the capacity of the economy to grow stem from its effects upon the demand for goods, not from its effects upon the capacity of the economy to produce goods, though the latter effects are obviously of great importance. Once demand exists, efforts to raise output will be stepped up. In the absence of sufficient demand, however, efforts to raise capacity will be limited. Hence, it is better on the whole that demand have a slight tendency to outrun productive capacity than that productive capacity tend to outrun demand.

Technological research affects both the demand for consumer goods and the demand for capital goods. It affects the demand for consumer goods by developing new kinds and varieties of consumer goods that people desire to incorporate into their standard of consumption. People acquire these additional goods by going into debt, by drawing on accumulated savings, or simply by saving a smaller proportion out of any given income. As a result, rising per capita incomes in the United States have not produced a drop in the ratio of incomes that have been saved. In the American economy, personal consumption expenditures have always been an important income-determining influence, contrary to the theory of Keynes, who held that consumption expenditures are a stable function of real per capita national income. If the view of Keynes were correct, consumption expenditures would be merely income-determined, not income-determining.

It would be a mistake to ascribe dynamic standards of consumption solely to the attractive products made possible by technological research, though in recent years this source of dynamic consumption standards has been growing rapidly. But specialized technological research, as I have pointed out, had very limited importance until about 25 years ago, and consumers have been a dynamic influence in the United States since time immemorial. Most of the population has been motivated by strong desires to get ahead, and this ambition has made all aspects of life in the United States, including consumption, strongly competitive. Various features of the American environment have stimulated ambition and competition: the absence of tradition and social stratification, the rapid growth of population (especially up until the end of the 19th century), and the abundance of economic opportunities created by the immense resources awaiting development. But, as the rate of population growth has dropped and as natural resources have become more fully developed, technological change has become a more important source of opportunity, keeping vigorous the strong ambitions and competitive spirit of early days.

A little more than half a century ago, there was widespread belief that, with the filling up of the continent and with the passing of the frontier, the United States would become like Europe with a stratified society in which a class struggle would emerge. But this has not happened, largely because of the accelerating rate of technological change beginning about the middle of the 19th century. Of course, the accelerating rate of technological change did not depend to a large extent upon full-time, specialized research workers until about the second quarter of the 20th century. In earlier days, much important research was done by brilliant self-trained men ("inventors") and much more work of great importance was done by technically trained operating men. But though many of the operating men did excellent research, they were unable to give full time to research problems. The recent development of full-time, specialized research must be regarded simply as a far more efficient method of doing what industry had previously been doing on a fairly substantial scale.

I do not assert that the rise in technological research is attributable to the decline in the rate of population growth or to the fact that natural resources had become rather well developed. Perhaps there was a causal relationship between these developments, and perhaps there was not. Until these matters are better understood, it is preferable to regard the timing of the rise of technological research as a happy accident of history.

No one, of course, knows what would have happened had technological progress made much smaller additions to the number of products of industry. Suppose that the automobile, the radio, television, a host of household electrical appliances, home movie cameras, and other things had not been invented and developed. Everyday living would obviously have been very different from what it is now. Perhaps we should have had a civilization superior to our present one—one in which men would be more interested in ideas and less interested in things. An attempt to argue the pros and cons of such issues would take me far afield. It is reasonable to suppose, however, that a much smaller variety of things to buy and to use would have led men to be more interested in leisure and less interested in income than they are today. The working week would have fallen faster. The present eager desire for more income stems largely from the facts that industry, through technological research, is able to offer the people a much wider variety of goods than they are able to purchase and that new and improved goods are constantly being offered for sale.

Thus, technological research has had two offsetting effects on the length of the working week. By developing efficient machinery, it has tended to reduce the value of goods relative to leisure and to bring about a reduction in the length of the work week. By increasing the variety of goods, it has tended to raise the value of goods relative to leisure and to retard the drop in the length of the work week. Between 1929 and 1956 the proportion of disposable income spent on user-operated transportation, household appliances, boats, pleasure craft, sporting equipment, radio and television receivers, and radio and television repairs increased from 9.13 percent to 12.7 percent. Much of the success of these parts of industry in getting a larger share of incomes after taxes must be explained by the development of products and services for which specialized technological research is responsible. Thus, technological development has helped to hold down personal savings in the face of rising per capita real incomes.

Demand for Capital Goods

Technological research affects the demand for capital goods in two ways: by developing new consumer goods that require new plants and equipment for their manufacture, and by the developing of new processes and new equipment

that represent opportunities for investment.

The capacity of technological research to create investment opportunities reminds us of how unsatisfactory have been the economists' theories of investment. Economists have pretty much taken the volume of investment opportunities as given and have had little to say about the determinants of the volume of investment opportunities. There have been a few observations about the effects of undeveloped natural resources and the growth of population upon the supply of investment opportunities. Keynes has a chapter on the state of long-term expectations in which he discusses "some of the factors which determine the expected yield of an asset" (*1*, p. 147). Among the factors determining the prospective yield, Keynes mentions "future changes in the type and quantity of the stock of capital assets." This is about as near to technological research as he gets at any point in his book.

It did not occur to Keynes, any more than it has occurred to most other economists, that special efforts directed toward the specific purpose of creating investment opportunities might be fruitful and highly profitable and might, indeed, be the basis for a large and growing industry. So low was Keynes's estimate of the capacity of the economy to create investment opportunities that he ventured the opinion that in a highly developed community in which population is not increasing, the increase in the stock of capital might bring down the marginal return on capital to approximately zero within a single generation (*1*, p. 220). Keynes conceded that the changes in technique could in theory postpone this result, but his views of practical policy indicated plainly that he did not expect technological change to avert stagnation. According to his view, only a chronic government deficit would do the trick.

At this point we must consider the significance of the part of technological research that I have called the industry of discovery. I have described the product of the industry as knowledge. But let us be more specific about this. The product of the industry consists in large part of investment opportunities. In other words, here we have a large and rapidly growing industry which is devoted largely to discovering or creating investment opportunities. Obviously, from now on, economists, in constructing a theory of investment, must put the industry of discovery at the top of the list of investment determinants. In an age of research the capacity of the economy to discover investment opportunities depends in the main upon (i) the fund of knowledge that has been accumulated and is available to be drawn on, and (ii) the volume of resources devoted to the industry of discovery.

Of crucial importance is the question of how much larger the industry of discovery is likely to grow relative to the gross national product. Space does not permit a rounded discussion of this question, and my limited knowledge of the problem restricts me to a few scattered observations. The value of the current product of the industry of discovery, to the community as a whole at least, may be expected to grow for the reason that I have already mentioned, namely, the fact that the greater the population of existing truths, the better is the prospect that any addition to this population will produce useful relationships between propositions. But the extent to which the industry of discovery can profitably grow depends upon (i) the extent to which the makers of discoveries can appropriate the gains from them, and (ii) the cost of making discoveries. The time may come within a few decades when a further expansion of the industry of discovery relative to the gross national product is not profitable to private industry. Certainly, the scale of research that private industry can afford is bound to be far less than the amount that would be justified by balancing gains to the entire community against costs to the entire community. But the day when the marginal returns of research to private enterprises merely balance the marginal costs is undoubtedly some decades away, at least in most industries—especially in many industries which have not as yet made much of a start on specialized research.

Stability of the Economy

How will the rise of specialized, technological research affect the stability of the economy? In general, technological research will contribute to stability, though it cannot be depended upon alone to produce stability.

The growth of specialized, technological research will promote stability in two principal ways. In the first place, research tends to introduce into many parts of industry the sort of technology that must be financed by long-range plans which ignore the business cycle. In the second place, technological research greatly increases the number of industries in the economy, and this, in itself, is a stabilizing influence. It is difficult, if not impossible, to eliminate fluctuations in the spending of individual industries on plant, equipment, and inventories. Hence, each industry has cycles more or less of its own, depending upon the value of the accelerator and the multiplier in the particular industry and upon the sensitivity of the investment plans of the industry to outside events. The important point is that no two industries have the same cyclical patterns or the same sensitivity to outside events. The larger the number of industries in the economy, the greater is the chance that the upward and downward movements of the economy will be sluggish resultants of averages derived from the nonsynchronized cycles of the many industries in the economy. Hence, by adding to the number of industries, technological research tends to moderate the cyclical movements of the economy as a whole.

A special word should be added about the possibility of technological research's helping industries adapt their current production to market changes. The present plight of the automobile industry serves to illustrate the point. The technology of the automobile industry is of such a nature that the industry is from two to three years away from its market; that is, important changes in models need to be frozen anywhere from 2 to 3 years in advance of the models' being put on sale. In spite of this fact, the industry has attempted to develop the automobile as a style good, placing great emphasis upon year-to-year model changes. The industry needs to put its engineers hard at work to change its technology in ways that will permit prompter changes in its models when, as in 1958, it misjudges the tastes of consumers. There are many other industries which could advantageously use their engineers to modify their technology to make possible a quicker adaptation of the industry's product to changes in consumer preferences, and also to make possible greater variety in product lines at any given moment to meet the preferences of minority groups of consumers.

The rise of specialized, technological research raises important economic questions that are interesting, alike from the standpoint of practical policy and economic theory. Let me discuss briefly a few of these questions.

1) May technological research be ex-

pected to maintain full employment fairly steadily by helping the economy keep the proper relationship between the volume of investment-seeking funds and the volume of investment opportunities?

Will not technological research, by raising per capita incomes, create a propensity to save that is too large in relation to the rate of discovery of new investment opportunities? One can say that this result is extremely unlikely, although one cannot assert that as a matter of economic theory it is impossible. A chronic excessive propensity to save could be maintained only through a growing desire to hold liquid assets. Technological discovery is itself a powerful enemy of liquidity preference, because it is constantly offering people new and more attractive goods and services to buy and new and more attractive ways to use their leisure. Powerful and special circumstances would be necessary to permit the preference for liquidity to prevent people from buying the new and more attractive goods and services which technological research makes possible. Furthermore, the larger the stock of automobiles, houses, and household appliances, and the greater the use of the various services (airplane travel, for example) that technological research has made possible, the greater becomes the advantage in spending money on research designed to make the existing stocks of goods or existing processes obsolete. And what applies to consumer goods applies also to industrial equipment: the larger the existing supplies, the more advantageous it is to expand research in order to make these stocks obsolete.

2) In view of the fact that the period since 1929 has seen an enormous rise in technological research, why have the rate of interest and the rate of profit been falling? The proportion of gross savings to the gross national product was about the same in 1956 and 1957 as in 1929: about 16.0 percent in 1929, 15.8 percent in 1956, and 15.0 percent in 1957. Nevertheless, both interest rates and corporate profits were considerably lower in 1956 than in 1929. For example, the return on AAA bonds dropped from 4.73 percent in 1929 to 3.36 percent in 1956, and 3.89 percent in 1957. Corporate profits, after corporate income tax liability and after inventory valuation adjustment, dropped from 6.1 percent of corporate sales in 1929 to 2.7 percent in 1956.

The explanation of the drop in interest and profits is found, I believe, in a cost-profit squeeze resulting partly from higher corporate profits taxes and partly from higher wages. In 1929 corporate profits tax liability was 3 percent of all income originating in corporate business, and in 1956 it was 11.6 percent. And the compensation of employees as a percentage of income originating in corporate business, less corporate profits tax, was 76.9 in 1929 and 89.4 in 1956. In a nutshell, government and labor just increased their shares a little too fast for the engineers and scientists, reducing the proportion of income available for profits.

3) Is there a close relationship between the parts of the economy where discoveries are made and those where increases in productivity occur? There is not, and there is no reason why there should be. Many of the most important technological advances are made in order to sell more goods—by the suppliers of the industry that experiences the gain in productivity. The printing industry plays only a limited role in developing printing presses; the railroads did not develop the diesel locomotive (in fact, they almost had to be forced to try these locomotives); the coal industry does not develop the mining machinery that it uses. The part of the economy that has been gaining most rapidly in productivity in recent years has been agriculture, but the sources of this gain are not on the farms.

4) How great is the need for the support of technological research outside the industry of discovery, that is, for the support of research that has to be justified by benefits to the entire community rather than by profits to the discoverer of knowledge? The answer to this question is fairly plain, and I ask it mainly to remind you of its importance. The discovery that an enormous amount of research can be carried on for profit is surely one of the most revolutionary economic discoveries of the last century, and, as I have pointed out, it has enabled research to command far greater resources than would otherwise be available for it, and has led to the spectacular boom in research. But the rapid rise of the industry of discovery does not alter the fact that the community as a whole can afford research on a far larger scale than the sum total of the research projects that private industry can afford.

By and large, the government has shown a grossly inadequate appreciation of the importance of research to the community. Government research expenditures, it is true, are large and have been growing rapidly, but they have been forced mainly by military considerations. The crimes, first of Hitler and later of Russia, have forced our government to do research that it had lacked the initiative and imagination to attempt. Fortunately, much of the military research has civilian applications.

But outside the field of military research, government support of research is only a small fraction of the amount that would yield enormous returns to the community. Indeed, it is safe to say that there is no field where larger government expenditures would produce as rich a return as greater outlays on research—and also on the necessary foundations for research, the education of talented people. Perhaps it is unreasonable to expect the members of Congress and the members of legislatures to see this fact clearly without assistance from the scientists themselves. To help the government policy-makers appreciate the nation's need for greatly enlarged government research outlays outside the military field is one of the responsibilities of the National Science Foundation. It is a great national asset that the country has this Foundation to help the country make wise use of its resources.

Reference

1. J. M. Keynes, *General Theory of Employment, Interest, and Money* (Harcourt, Brace, New York, 1936).

News of Science

Young Research Workers Sought for Washington Area Laboratories

The Civil Service Commission has begun a nationwide search for more than 200 of the country's most capable young men and women who have recently received their degrees in engineering, mathematics, and the physical sciences. The applicants, who must pass a newly designed examination, will be offered a starting salary of $5430 and the opportunity to work at research with many of the country's leading scientists in 11 federal laboratories in the area of Washington, D.C. The new program marks a significant departure from standard recruiting procedure in that it offers higher pay, better assignments, and more thorough and imaginative testing of the applicant's research potential. Further, virtually all candidates who meet the requirements of the examination will be considered for appointment.

Origins of the Program

The need for productive and creative research personnel is so great, both throughout the nation and at the 11 laboratories, in particular, that the Civil Service Commission, in conjunction with many government scientists, devised a new approach to the problem of recruiting. While maintaining the old system of recruiting by which an applicant is judged on the basis of his college record, is not required to take an examination, receives in most cases a Civil Service rating of GS-5 with a salary of $4480, and is not assured a research position, the commission has created a new category to give the prospective scientific employee another option. Under this arrangement the candidate can choose to take the new Research Scientist Examination which tests both his knowledge of the appropriate subject matter and his ability at mathematical formulation. Given success in this examination, the candidate will be offered appointment to Civil Service grade GS-7 with a salary of $5430 and can expect assignment to one of the 11 Washington area laboratories, working in the research field of his choice under top-ranking scientists. The new category, with its flexible placement policy, offers the candidate, in addition to the higher salary, a very good possibility of gaining the advantages that lead to what has been called "psychic income"—the opportunity to discover and to do constructive work on important problems, adequate recognition of work well done, a high caliber of supervision, and a reasonable degree of security.

Research Scientist Examination

In its effort to identify and then place applicants of the ability which it is seeking, the Civil Service Commission will use two examinations and a questionnaire. All applicants will be required to take a subject matter examination in either chemistry, physics, or mathematics, or a combined physics-chemistry test which consists of general physics, qualitative and quantitative analysis, and physical chemistry. In addition, all applicants will be required to fill out a background information questionnaire which will be used to help the 11 scientific laboratories decide what type of work might be most suitable and attractive to eligible candidates. The questionnaire will also ask the candidate to indicate the kind of research job and the laboratory in which he would prefer to work. Because of the limited number of applicants being sought and the nature of the recruiting program—finding persons with research potential for research positions—the successful applicant will have an excellent opportunity for assignment to the laboratory and the work he chooses.

The most significant element of the commission's testing program is the mathematical formulation test. This test, which will be required of all applicants, will attempt to identify those persons who have a high degree of potential research ability. Ten previous studies have been drawn upon by the commission's testing experts to devise this examination. In four studies research workers have been examined in conjunction with nonresearch workers. In six other studies research workers of a high degree of creativity and productivity, as identified by their supervisors, have been examined in conjunction with other research workers. Both cases have resulted in the identification of stable and significant differences between the two groups under study. The mathematical formulation test will examine for those differences and by this means attempt to be predictive of a given individual's future research potential. In later years the commission will follow the careers of the researchers selected under this program to check the validity of its predictive techniques.

The test by which the candidate will demonstrate his ability to develop the mathematical formula needed to solve a quantitative problem will consist of 25 questions of a nature indicated by these two examples: (i) A door opening was 3 feet 9 inches higher than it was wide. Which one of the following best expresses the area of the door opening, in square inches, after the opening has been heightened 2 inches and narrowed 3 inches? (x is equal to the original width of the door.)

A) $lc + (x/w)$ B) $l + (w/cx)$
C) $l + (cw/x)$ D) $(l + cw)/x$
E) $(l + cx)/w$

(ii) The length l of a spiral spring supporting a pan is increased c centimeters for x grams of weight placed on the pan. What is the length of the spring if w grams are placed on the pan?

A) $lc + (x/w)$ B) $l + (w/cx)$
C) $l + (cw/x)$ D) $(l + cw)/x$
E) $(l + cx)/w$

Laboratories

The federal scientific facilities for which research personnel are being sought for career positions in the fields of engineering, chemistry, electronics, mathematics, metallurgy, and physics are currently engaged in a great variety of programs. The facilities and some of their programs are given below. Their locations are shown in Fig. 1.

David Taylor Model Basin. Located 6 miles northwest of Washington, the David Taylor Model Basin is the largest and most completely equipped research establishment of its kind in the world. The primary mission of the Model Basin is to determine from model tests the most suitable shapes and forms to be adopted for United States vessels, including aircraft. The Model Basin has four research laboratories. The hydromechanics laboratory is concerned with the behavior of floating and immersed bodies. It also carries on basic and applied research in fluid flow and underwater sound. The structural mechanics laboratory conducts theoretical and experimental investigations on problems relating to the structural strength of vessels and equipment and their responses to vibration, shock, and underwater explosions.

The aerodynamics laboratory engages in applied research and development testing to determine and improve the aerodynamic characteristics of powered and nonpowered models of rotary and

fixed-wing aircraft, guided missiles, and their components. The applied mathematics laboratory applies high-speed computer techniques to engineering, research, and logistic problems and carries out research in mathematics and in computer design and techniques.

Diamond Ordnance Fuze Laboratories. These Diamond Ordnance Fuze Laboratories are the principal research laboratories for the Department of Defense in the development of unique types of electronic fuzing and related items for application to guided missiles and other nonrotating projectiles. Research programs require the services of electronic scientists, physicists, mathematicians, chemists, and many types of engineers. The laboratories are located adjacent to the National Bureau of Standards in residential Washington.

Current programs include basic and applied research in electronic systems and components, fabrication and testing of prototype devices, developments of engineering specifications required for industrial production.

Engineer Research and Development Laboratories. The U.S. Army Engineer Research and Development Laboratories perform specialized research essential to the defense of the nation. Among current projects is research on optical, mechanical, electronic and analytical methods of determining target coordinates for surface-to-surface missiles, and for photogrammetric mapping. Basic and applied research programs are conducted on principles, techniques, and materials for the detection of buried and submerged mines. In the fields of radiation and illuminations, research at the laboratories covers phenomena, materials, and techniques in the ultraviolet, visible, and infrared portions of the electromagnetic spectrum. Long-range research on the influence of various energy forms such as electromagnetic radiations and particle bombardment upon solids is being carried on to determine the true nature of explosives. An important field of applied research is the investigation of the effects of atomic, biological, and chemical warfare on Corps of Engineers equipment. Applied research is also performed on gas-generating and storage equipment, industrial engines, earth-moving operations and winterization, as well as on all types of fixed and floating bridges.

National Bureau of Standards. The National Bureau of Standards plays a unique role in the nation's scientific community. In fulfilling its primary responsibility—development and maintenance of the national standards of physical measurement—the bureau has become one of the principal federal agencies engaged in basic and applied research in physics, chemistry, mathematics, and engineering. More than 1100 professional scientific staff members perform research on over 1000 technical and scientific projects, such as cryogenic engineering; ionospheric, nuclear, and solid state physics; optics, and thermodynamics: This broad research program, covering almost every area of the physical sciences, including most of the specialties in chemistry, classical and modern physics, pure and applied mathematics, and metallurgy, offers oppportunities for the recent graduate to select the field of work of his greatest interest. The laboratories are located on a 68-acre campus-like site in residential, northwest Washington. Because the basic program of the National Bureau of Standards has international significance in the field of measurement, scientists at the bureau often develop world-wide contacts in the course of their careers.

National Institutes of Health. The National Institutes of Health are in Bethesda, Md. The seven institutes and the clinical center—a 500-bed research facility—comprise the major research branch of the Public Health Service of the Department of Health, Education, and Welfare. During the past few decades, NIH has conducted research in all types of medical and related sciences. The major concern is with the chronic illnesses—cardiovascular diseases, cancer, mental and neurological disorders, and various rheumatic, metabolic, dental, and infectious diseases. Research chemists, physicists, and electronic scientists at NIH participate in research in every field of scientific endeavor. Serving the investigators who plan and conduct research are such auxiliary departments as the centralized instrument shop, animal production colony, and scientific library.

Naval Air Test Center. The Naval Air Test Center located at the mouth of the Patuxent River on Chesapeake Bay consists of 6800 acres of land with facilities for landing all types of naval aircraft. The diversified test facilities of the Naval Air Test Center provide opportunities for original contributions in theoretical and experimental development of test methods, for design of new instrumentation and facilities, and for application of data to requirements for future airplanes and their equipment.

Naval Gun Factory. The U.S. Naval Gun Factory is the world's largest naval armament plant. It is located in Washington, on the banks of the Anacostia River and is Washington's largest industrial organization. This plant undertakes programs related to the development and prototype manufacture of underwater, surface, and air weapon systems.

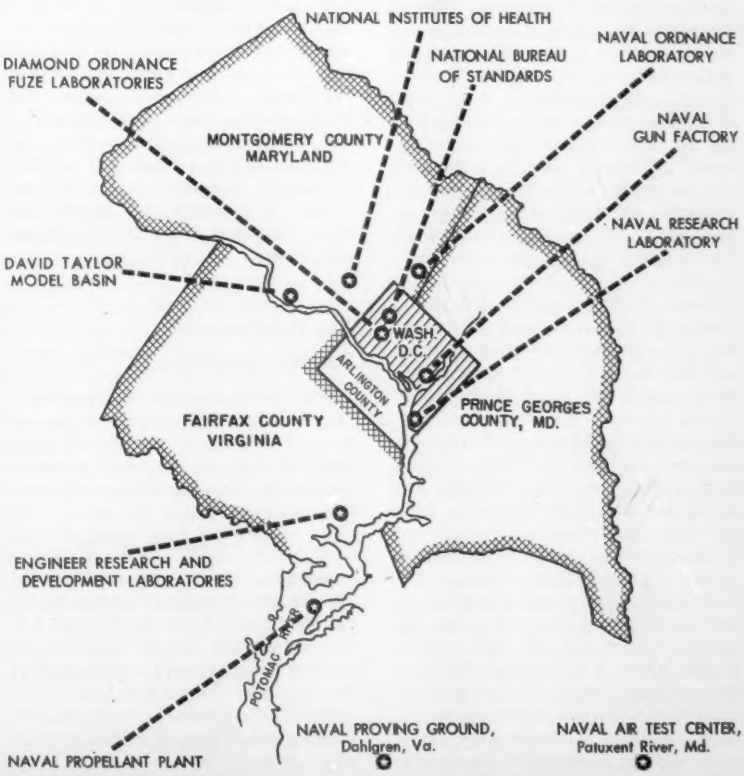

Fig. 1. Locations of 11 federal research laboratories in the Washington area. The most distant is about 50 miles from the Capitol.

These programs embrace the research and development phases through to tactical fleet use. Present programs include applied research, development, and evaluation of missile launching systems, depth bombs, mines, optical equipment, and high performance aircraft weapons. The Naval Gun Factory conducts research development and evaluation programs on engineering materials and on the processing of these materials. The Naval Gun Factory is expanding its research staff in the fields of physics, chemistry, metallurgy, and electrical, electronics, mechanical, and materials engineering. Diversified programs and a progressive management offer excellent opportunities for promotion and recognition in various scientific fields.

Naval Ordnance Laboratory. The Naval Ordnance Laboratory is located about 11 miles north of Washington, in Silver Spring, Md. Here the Navy has established a fully integrated research and development facility capable of pursuing weapon development from the first feasibility study to the state of readiness for combat use. NOL scientists and engineers conduct and supervise research, development, experimental manufacture, evaluation, pilot production, and project assistance both at the laboratory and in leading industrial plants of the nation. This laboratory conducts a one-year professional development program for recent graduates wherein they are given an opportunity to work in research, engineering, and evaluation assignments before a determination is made about the type of physical science or engineering they wish to pursue. The Naval Ordnance Laboratory also has a graduate training program coordinated with the University of Maryland in which an M.S. and Ph.D. degree may be obtained. The majority of the courses are taught at NOL.

Naval Proving Ground. The Naval Proving Ground is engaged in developing new and improved types of naval ordnance through research and development programs in the fields of mathematics, physics, chemistry, metallurgy, and engineering. Efforts are devoted not only to developing ordinary weapons such as guns, projectiles, rockets, and bombs, but also to developing the newest types of weapons which represent the application of the latest advances in science to problems in ordnance. Extensive experimental and testing equipment is developed and used in the numerous laboratories of the proving ground. There is a continuing need for well-qualified persons in the field of mathematics, physics, chemistry, metallurgy, mechanical engineering, electronic science, aeronautical engineering, and electrical engineering. The Naval Proving Ground is situated on the Virginia side to the Potomac River, approximately 50 miles south of Washington and 30 miles from Fredericksburg, Va.

Naval Propellant Plant. The Naval Propellant Plant, located about 20 miles south of Washington, is engaged in research on and development of propellants for guided missiles, rockets and guns, and in the techniques for loading these into rocket motors. The plant is also engaged in the development and use of production techniques for the manufacture of the propellants and for the loading of the rocket motors for most of the Navy's rockets and guided missiles. The Propellant Plant is organized and equipped to study all phases of propellant research and development, including the synthesis of new formulations, the improvements of present propellant compositions and configurations, the production of pilot "lots" of new propellants for developmental and evaluation purposes, and the conduct of surveillance studies on the stability of propellants and propellant formulations.

Naval Research Laboratory. The Naval Research Laboratory, which is located on the banks of the Potomac River in southwest Washington, conducts applied research and development to meet immediate needs of the Navy and engages in fundamental research in anticipation of future needs. A listing of the scientific fields—applications, research, astronomy, astrophysics, chemistry, electricity, mathematics, mechanics, metallurgy, ceramics, nuclear and atomic physics, radio, solid-state physics, and sound—indicates the breadth of this program. Research equipment at NRL is modern, extensive, and is supplemented by complete shop facilities for the construction of scientific apparatus and models.

The President and Scientific Information

The President approved a plan on 7 December that is designed to help meet the critical needs of the nation's scientists and engineers for better access to the rapidly mounting volume of scientific publication.

NSF Information Service

Acting upon the recommendations of his Science Advisory Committee, the President directed that the National Science Foundation take the leadership in bringing about effective coordination of the various scientific information activities within the Federal Government. The President asked that all federal agencies whose programs involve scientific information cooperate with and assist the National Science Foundation in improving the government's own efforts in this area.

The action by the President strengthens and reinforces the provision of the National Defense Education Act of 1958 calling for the establishment of a Science Information Service in the National Science Foundation to "provide, or arrange for the provision of, indexing, abstracting, translation, and other services leading to a more effective dissemination of scientific information, and undertake programs to develop new or improved methods, including mechanized systems for making scientific information available."

The committee urged that fullest use be made of existing information services, both public and private, and that the foundation's Science Information Service supplement rather than supplant present efforts.

Dimensions of Publication

James R. Killian, Jr., special assistant to the President for science and technology and chairman of the Science Advisory Committee, commented on the growing dimensions of world scientific publication and pointed out that it has become a problem requiring action at the national level. Killian said:

"Science and engineering are largely built on the published record of earlier work done throughout the world. There are for example, 55,000 journals appearing annually, containing about 1,200,000 articles of significance for some branch of research and engineering in the physical and life sciences. More than 60,000 different books are published annually in these fields, while approximately 100,000 research reports remain outside the normal channels of publication and cataloging. Within this vast body of world-wide scientific information, published and unpublished, lie the technical data that scientists need in order to do their work. The situation is further complicated by the fact that a large and important proportion of the world's scientific literature appears in languages unknown to the majority of American scientists, such as Russian and Japanese."

In its recommendations, the President's Science Advisory Committee outlines a program calling for the review, coordination, and stimulation, on a nationwide basis, of activities in the areas of primary and secondary publications, scientific data centers, unpublished research information, storage and retrieval, and translation by mechanical means.

New Agency Unnecessary

No new agency will be required to carry out the recommended program. Under its enabling act, the National Science Foundation has devoted special attention to the information needs of scientists and has developed a series of

programs designed to help meet those needs.

At least ten other federal agencies are engaged in abstracting and indexing, translating, preparation of technical reports, and research related to information needs. These agencies are asked to cooperate in providing or arranging for acquisition and reference programs, clearinghouse functions, and evaluation studies of existing programs. Research on new and improved methods of information handling will be emphasized, and the Department of State will take the lead in encouraging cooperation among the United States, foreign, and international scientific information organizations.

Subcommittee on Scientific Information

The President's Science Advisory Committee considered the whole problem of such importance that earlier this year it appointed a special subcommittee to consider the subject at length. Headed by W. O. Baker, vice president (research), Bell Telephone Laboratories, the subcommittee comprises the following members: Curtis Benjamin, president McGraw Hill Book Company; Caryl P. Haskins, president, Carnegie Institution of Washington; Elmer Hutchisson, director, American Institute of Physics; Warren C. Johnson, dean, Division of Physical Sciences, University of Chicago; Don K. Price, dean of the School of Public Administration and Littauer professor, Harvard University; H. Scoville; and Alan T. Waterman, director, National Science Foundation.

In submitting its findings, the subcommittee paid special tribute to the work of individual scientists and engineers in selecting, interpreting, and abstracting scientific and technical information. It noted the fact that the services rendered by many of the scientific societies and professional institutions to the scientific community in the information field are world famous for their quality. It expressed the hope that such private groups would continue to cooperate with and assist the Federal Government in the achievement of long-range solutions to scientific information problems. The subcommittee's conclusions form the basis for the recommendations submitted to the President by the Science Advisory Committee.

Pioneer III

The United States space probe rocket Pioneer III, which was fired from Cape Canaveral, Fla., on 6 December, reentered the atmosphere and burned up due to aerodynamic heating on 7 December, after a flight of 38 hours, 6 minutes. William H. Pickering, director of the Jet Propulsion Laboratory, operated by California Institute of Technology for the National Aeronautics and Space Administration, made the following statement about the results of the flight.

"Pioneer III . . . provided us with an unexpected dividend of information of great value. The Puerto Rico Tracking Station was in contact with Pioneer III . . . until it fell below the Puerto Rico horizon on its long journey back to earth. Puerto Rico lost the signal from the probe . . . when it was approximately at 2000 miles altitude above the earth over French Equatorial Africa.

"This means, of course, that the telemetry from the probe was heard by Puerto Rico as the probe passed through the radiation belt discovered by the Explorer satellites. The telemetry tapes from Puerto Rico for both the launch and the trip back to earth show solid data which will give us, for the first time, information as to some of the energy levels in the radiation belt as well as some idea of the physical limits of the belt.

"While the results of the launch of Pioneer were disappointing to the engineering specialists in that the probe did not reach the moon, the scientific benefit to be obtained from this dividend of two long instrumented passes through the Van Allen radiation belt more than compensates for this disappointment.

"I am greatly pleased with this significant result of the experiment, as well as by the evidence that the tracking network proved itself most efficiently. The large computer at the Jet Propulsion Laboratory in Pasadena was able to predict most accurately the time and place when Pioneer III would rise like a star on the horizon so that the tracking antenna at Goldstone and Puerto Rico could be positioned to receive the signal.

"Telemetry also shows that the method used by JPL to control the interior temperature of the instrumentation also worked perfectly. White paint was used on the outer surface of the probe to control the amount of heat received from the sun and the amount radiated to space. In order to preserve the instrumentation, it was necessary to control the temperature within 10 and 50 degrees Centigrade. Telemetry shows that the temperature reached 43 degrees Centigrade (100 degrees Fahrenheit) shortly after launch and remained at that level throughout the life of the probe."

AAAS Board of Directors

The Council of the American Association for the Advancement of Science has elected Chauncey D. Leake, assistant dean of the College of Medicine at Ohio State University, as president-elect of the Association. Leake has been a member of the Board of Directors since 1955, a member of the Publications Committee since 1955, and chairman of the Committee on the Social Aspects of Science since 1957. In 1942 and 1954 he served as vice president and chairman of Section L—History and Philosophy of Science.

H. Bentley Glass, professor in the department of biology at Johns Hopkins University, was elected as a member of the Board of Directors, and Margaret Mead, associate curator of ethnology at the American Museum of Natural History, was elected to a second 4-year term on the board.

The new officers will begin their terms on 15 January 1959.

Grants, Fellowships, and Awards

General. The National Academy of Sciences–National Research Council has announced a program of postdoctoral resident research associateships to be offered for 1959–60. The participating laboratories are the National Bureau of Standards (Boulder, Colo., and Washington, D.C.); the Naval Ordnance Laboratory (White Oak, Silver Spring, Md.); the Naval Research Laboratory (Washington, D.C.); the Navy Electronics Laboratory (San Diego, Calif.); and the U.S. Army Chemical Corps Biological Warfare Laboratories (Fort Detrick, Frederick, Md.).

The Air Research and Development Command is also participating in this program at four Air Force installations. These associateships are tenable at Air Force Cambridge Research Center (Bedford, Mass.); Air Force Missile Development Center (Alamogordo, N.M.); Rome Air Development Center (Rome, N.Y.); and Wright Air Development Center (Dayton, Ohio). In addition, the ARDC is sponsoring a program of postdoctoral university research associateships tenable at 21 universities in the United States.

The resident research associateships have been established to provide young scientists of unusual ability and promise an opportunity for advanced training in basic research in a variety of fields. Modern facilities are available in specified areas of the biological, physical, and mathematical sciences, and engineering. In addition to the above, research in certain areas of psychology is available.

Applicants must be citizens of the United States. They also must produce evidence of training in one of the listed fields equivalent to that represented by the Ph.D. or Sc.D. degree and must have demonstrated superior ability for creative research. Remuneration for these associateships is from $5985 to $7510 a year, subject to income tax.

Application materials may be secured by writing to the Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C. Applications must be filed at the Fellowship Office before *19 January 1959*. Awards will be announced about 1 April by the participating laboratories and research centers.

Teaching. The National Science Foundation has announced the initiation, on an experimental basis, of a program to encourage appropriate groups to set up specially devised study opportunities in the fields of science and mathematics for secondary school students of high ability. Proposals are invited from colleges, universities, and nonprofit research organizations for the summer of 1959. Proposals sponsored by secondary schools are not eligible under this program. However, the facilities of secondary schools can be utilized in college-sponsored, off-campus programs where this is mutually acceptable.

A wide variety of programs will be supported, including but not limited to one or more of the following features: classwork, laboratory visits, field trips, special orientation lectures in the fields of scientific endeavor, and research participation activities in which students work with experienced scientific investigators.

Under this program foundation support may include expenses of some or all of the student participants for room, board, travel (including commuting), and other essential items. Support may also be given for costs of the sponsoring institution. Direct costs may include fractions of staff salaries properly attributable to the program, payments to high school science teachers as auxiliary participants and counselors, and other necessary administrative expenses and supply costs.

Proposal for 1959 summer programs of this type must be received not later than *5 January 1959* by the Special Projects in Science Education Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Suggestions for the preparation of proposals are available from the same source.

Travel grants. The National Science Foundation will award individual grants to assist in defraying travel expenses for a limited number of scientists to the following scientific meetings: International Conference on Coordination Chemistry, sponsored by IUPAC, London, 6–11 April 1959—application deadline, *19 January 1959*; International Symposium on Electrolytes, sponsored by the Italian Society for the Progress of Science, Trieste, 4–8 June 1959—application deadline, *2 February 1959;* International Symposium on Fluorine Chemistry, sponsored by the Chemical Society of London, Birmingham, England 15–17 July 1959—application deadline, *2 February 1959*; Meeting of the European Molecular Spectroscopy Group, Bologna, Italy, 24–29 August—application deadline, *2 February 1959;* 17th International Congress of Pure and Applied Chemistry, Munich, Gremany, 30 August–6 September 1959—application deadline *2 February 1959*.

Scientists in the News

CHIEN-SHIUNG WU, professor of physics at Columbia University, is to receive the 1958 Research Corporation Award for her valuable contribution to the knowledge of beta-decay and particularly for her part in research that resulted in the overthrow of the "parity law." Dr. Wu is the first woman to receive the annual $2500 award, which will be presented in January.

The recently held parity law stated that objects which are mirror images of each other must behave in the same way. Tsung-Dao Lee, of Columbia, and Chen Ning Yang, of the Institute of Advanced Study at Princeton, N.J., Dr. Wu's Nobel Prize-winning collaborators, suggested that the validity of the law in weak interactions should be checked. Dr. Wu, together with coworkers, devised and carried out an unequivocal proof and thus backed up the Lee-Yang contention with experiments that proved the failure of the law. Her experiments were conducted with the cooperation of Ernest Ambler and co-workers at the U.S. Bureau of Standards in Washington, D.C.

THOMAS B. MAGATH, senior consultant in clinical pathology, Mayo Clinic, and professor of clinical pathology, Mayo Foundation, University of Minnesota, was awarded the Ward Burdick Medal "for the most meritorious contribution to Clinical Pathology" at the recent meeting of the American Society of Clinical Pathologists. He delivered the Burdick lecture on "The Antigen of Echinococcus."

E. TRIER MORCH, professor of surgery and director of the section on anesthesiology at the University of Chicago for the past 6 years, has been made chief and professor of anesthesiology at Cook County Hospital, Chicago.

ROBERT E. MAIZELL has been named to the staff of the American Institute of Physics to direct research on the problems of publishing and documentation in the field of physics. Maizell, who has been in charge of the Research Library of the Olin Mathieson Chemical Corporation's Industrial Chemical Division in Niagara Falls, N.Y., is at the institute under a grant from the National Science Foundation and supplementary funds from the Atomic Energy Commission.

Colonel JOHN H. RUST, chief of the veterinary pathology section of the Armed Forces Institute of Pathology, retired on 1 December and has become a member of the staff of the Massachusetts Institute of Technology. There he is to serve as director of a recently inaugurated research project sponsored by the Atomic Energy Commission that relates to new and extended uses for radioisotopes in the food industries. His new duties will necessitate extended travels in the United States previous to making his headquarters in Cambridge, Massachusetts.

HOWARD GEST, associate professor of microbiology at Western Reserve University, has been appointed professor of microbiology in the Henry Shaw School of Botany at Washington University, St. Louis.

The New York Academy of Medicine has announced that HUBERTUS STRUGHOLD, professor of space medicine and adviser for research, U.S. Air Force School of Aviation Medicine, Randolph Air Force Base, San Antonio, Tex., will deliver the 1959 Hermann M. Biggs Memorial Lecture. The lecture, which will be on space medicine, will be presented on the evening of 5 February at the academy headquarters in New York. The Biggs lecture was established in 1925 by the family of H. M. Biggs, who served as health commissioner of both New York City and New York State and was responsible for many important advances in public health practice. He died in 1923.

C. WARREN THORNTHWAITE, director of the Laboratory of Climatology, Centerton, N.J., has been awarded the American Geographical Society's Cullum Geographical Medal. The award is made for exceptional research in the field of geography. It will be formally presented at a dinner of the society in New York on 20 January.

Thornthwaite is the originator of a system for classifying climates that has been adopted by scientists in many parts of the world. He is also noted for his experimental studies of the effects of microclimatic conditions on plant growth and crop yields. These studies have proved highly successful in their application to commercial market gardening.

Book Reviews

Brighter Than a Thousand Suns. A personal history of the atomic scientists. Robert Jungk. Translated by James Cleugh. Harcourt, Brace, New York, 1958. xiv + 369 pp. $5.

This is a thoroughly bad book which is so interestingly written that it is sure to be widely read, and thus to make a large contribution to spreading confusion and erroneous views about its subject. It is a story of the development of nuclear physics, through the war-time atomic bomb project, the postwar political struggles for domestic and international control of atomic energy, the controversy about H-bomb development, and the Eisenhower-Strauss persecution of Robert Oppenheimer. The book was first published in Germany and has already been published in translation in England.

It abounds with interesting anecdotes. But it is such a sloppy job that there is some serious error in nearly every one of the anecdotes about incidents of which I have personal knowledge. This leaves me quite without confidence in the correctness of the others. But the anecdotes are not important: they are just the spice that gulls the reader along so the author can slip in his thesis, with slanted writing in place of evidence.

The book is devoted to propagandizing the view that is stated in the opening paragraph of Chapter 7: "It seems paradoxical that the German nuclear physicists, living under a saber-rattling dictatorship, obeyed the voice of conscience and attempted to prevent the construction of atom bombs, while their professional colleagues in the democracies, who had no coercion to fear, with very few exceptions concentrated their whole energies on production of the new weapon."

The proposition that "good" German scientists sabotaged the Nazi war effort in this respect is first explicitly stated on page 88 and developed to the end of Chapter 6. The thesis is that Werner Heisenberg and C. F. von Weizsäcker, as heads of the German uranium project, deliberately refrained from development of the bomb. A careful reading of these pages shows no real evidence in support of this thesis. Jungk says (page 88): "Most of those concerned have themselves preferred, for the sake of discretion and tact, to restrict mention of this delicate affair to a somewhat narrow circle." Clearly this statement is intended to influence the reader not to expect evidence, inducing him to understand why none exists, and therefore uncritically to accept the thesis on the basis of Jungk's reiterated assertion of it.

Several pages are taken up with a narration of a visit which Heisenberg made to Niels Bohr in Copenhagen in October 1941. Jungk calls this visit "a little-known peace feeler." Continuing (page 99) he writes: "By the expedient of a silent agreement between German and Allied atomic experts, the production of a morally objectionable weapon was to be prevented." After a long build-up that this was the purpose of Heisenberg's talk with Bohr, however, Jungk has finally to say: "But unfortunately he never reached the stage of declaring frankly that he and his group would do everything in their power to impede the construction of such a weapon if the other side would consent to do likewise."

After some more talk Heisenberg "nerved himself to assure the other with all the emphasis at his command that he knew it to be perfectly possible to produce such a weapon and that it could actually be manufactured, if a very great effort were made within a short time." On pages 102–104 is published a postwar letter from Heisenberg to Jungk about this incident. Nothing in this letter supports Jungk's thesis that the German scientists were trying to make an agreement with Allied scientists not to go ahead with bomb developments. Heisenberg merely says: "We did not know a process for obtaining uranium 235 with the resources available under war-time conditions in Germany, in quantities worth mentioning." Nothing in the letter supports the view that the Germans were not working at it wholeheartedly with the limited means at their disposal.

If in fact Heisenberg did intend to ask Bohr to get the Allies to refrain from developing an atom bomb, the available data are equally capable of being interpreted as having a pro-Nazi motivation: knowing that the means required for making an atomic bomb exceeded available German capability, then the next best thing in a strictly military sense would be to strike a moral pose and con the Allies into not making the bomb either. Such moral poses were commonly used by the Nazis who said they operated their slaughter-houses for Jews in an effort to purify the race.

From page 104 on, the thesis is regarded as established. Moral disapproval of the Allied scientists is then developed throughout the rest of the book.

As one who was deeply involved in the American program, I can say that everyone was primarily motivated by the fear that in Hitler's hands atomic bombs could lead him to achieve his goal of world domination. Austria, Czechoslovakia, Yugoslavia, Poland, Russia, Denmark, Norway, Sweden, Holland, Belgium, France, and the aerial raids on England: who can forget the threat to civilization of those Nazi hordes equipped only with "diplomacy" and "conventional" weapons? What might they not have accomplished with atomic bombs a thousand times more powerful than the TNT blockbusters? In the given situation, the highest morality, as we saw it, demanded devotion to the defeat of that terrible enemy.

In the postwar period, most of the atomic scientists have given much of their time and energy to alerting their fellow-men to the catastrophic dangers for humanity involved in a third World War—in preparation for which the major powers are spending such vast sums in their insane race toward doom. For such moral services to mankind, many of them have suffered and will suffer much more than those Germans who now are constructing a legend that their very real collaboration with Hitler was only a pretense.

In a wider sense, the most wicked thing about this book is its specious singling out of the atomic scientists for moral condemnation. All war, all hatred, all strife of any kind, is immoral. All human beings who do not work actively for peace and justice and brotherhood among men are the guilty ones, and alas, they are many. And they are guilty if they work so delicately "for the sake of discretion and tact" that their efforts have no noticeable effect whatever.

It is unfortunate that no group of really competent historians has yet undertaken to write a thorough, critical history of the fateful events surrounding the development of atomic weapons and the social and political problems to which their development has given rise. Time is moving on, memories of the living are fading, many of the principals are already dead, so the task becomes increasingly difficult. Does it become a

proper subject for historical research only after it is too late to do it properly? Lacking such a careful job, many will have to rely on Jungk's book for one version of the exciting and important story. But—*caveat emptor.*

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Negroes and Medicine. Dietrich C. Reitzes. Published for the Commonwealth Fund by Harvard University Press, Cambridge, Mass., 1958. xxxi + 400 pp. $7.

This book is the result of a research project conducted under the auspices of the department of sociology of the University of Chicago, through a grant from the Rockefeller Foundation. Reitzes directed the project and edited the findings.

The study is a systematic one, divided into two parts. The first part analyzes the enrollment patterns of Negroes in the nation's medical schools and compares the performance of Negroes on the Medical College Aptitude Test with that of white students and of applicants who were rejected. It points out the undergraduate origin of Negroes in the medical schools and indicates the changing pattern toward integration in the study of medicine.

Part I presents evidence which reveals that Negroes compare unfavorably with white medical applicants in Medical College Aptitude Test scores; that the rejected applicants of predominantly white schools compare well with applicants accepted in medical colleges whose primary orientation is toward Negroes; and that Negroes who are graduates of predominantly white premedical colleges are more readily accepted by white medical colleges than are those applicants who are graduates of schools oriented primarily toward Negroes.

Moreover, the median scores of students accepted at Meharry Medical College on the regional support plan are generally lower than the median scores of noncompact students who succeed in gaining admission. Despite the lower scores, the Negroes admitted to white as well as to Negro medical schools usually complete their studies and qualify for practice. The scores on aptitude tests reflect cultural differences between the two groups which stem from dualism.

The study indicates that a larger number of Negroes are being admitted to integrated medical colleges than in the past, but that the population is increasing faster than the rate of admissions, so that the critical plight of Negroes with respect to medical services is not being alleviated.

Contributing the largest number of the students who are admitted to Meharry Medical College, and also heading the list of Negro colleges in terms of its contribution of Negro students to white medical schools, is the small college of Morehouse. It ranks third in the total number of graduates accepted for the study of medicine at Howard University. It would appear that the climate and emphasis at Morehouse College might well be the key to a more general remedial measure in correcting the critical shortages in medicine.

The second part of the book is concerned with patterns of behavior in sampled communities in regard to hospital practices for internships, residencies, and staff affiliations. It also samples practices in regard to integration in medical societies and relationships in the area of specialization in medicine. It indicates improvement in professional opportunities for Negroes in internships, residencies, and staff affiliations. At the lower level of medical training and practices, the barriers are not as great as they are at the upper levels.

In communities which lack approved quasi-integrated hospitals, Negroes have not qualified in large numbers for board specialties. Where these hospitals have been late in developing, as in Atlanta, status and lack of intern training opportunities have postponed, if they have not entirely blocked, improvement of the qualifications of the Negro doctor.

This book will serve as a useful source of data for observing patterns of changes affecting the study and practice of medicine in various types of communities as well as on a nationwide basis. It presents these data lucidly and authoritatively and is therefore a valuable reference for persons interested in the field of race relations.

SAMUEL M. NABRIT
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A Field Guide to Reptiles and Amphibians of Eastern North America. Roger Conant. Houghton Mifflin, Boston, 1958. xv + 365 pp. Illus. $3.95.

The appearance of another—the twelfth—in the "Peterson Field Guide Series" is always a happy event for outdoor naturalists. This one covers 505 species and subspecies, of which 320-odd are reptiles. All but one—the rare leatherback turtle—have been illustrated from life, with drawings made from photographs by Isabelle Hunt Conant. More than 400 of these are in color, also from life.

Since the use of color for identification of "herptiles" is made tricky by the ability of some of them to change color from minute to minute, and since the field guide is like others in the series in relying heavily upon illustrations, special care has been given to pointing out similar species. Forty pages of distribution maps will help, too, in locating the right name and corresponding information for a specimen in hand.

Conant shows particular concern with handling specimens in such a way as neither to hurt the "herptile" nor endanger the holder. Yet he realizes that most specimens will be identified at far closer range than any bird, and that many a field naturalist will wish to keep specimens alive in captivity for further observation. For these reasons he includes short sections on the capture and care of specimens and on the treatment of snake bite.

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Quantitative Plant Ecology. P. Grieg-Smith. Academic Press, New York; Butterworths, London, 1957. x + 198 pp. Illus. $6.

Ecologists are attempting to describe communities and organism-environment relationships in more quantitative terms in order to meet the demands of ecosystem analysis and to place more of ecological investigation on an experimental basis. This book is an up-to-date survey of problems encountered in the quantitative approaches to plant ecology. The discussions in the book will be of interest to all biologists concerned with organism-environment relationships, especially to those working with organisms in noncontrolled environments.

This book has a balance of viewpoints that keeps the discussion in terms that are meaningful to ecologists. Appreciation for the service role of mathematical tools is complemented by an awareness of the large number of variables and their complex relationships in all problems relating to communities of organisms. The author recognizes the need for the fullest possible knowledge of the biology of individual species, and also for continued use of empirical approaches and approximate methods in poorly understood areas of investigation. Although the discussion focuses on problems with plants, the author draws upon much of the pertinent work in animal ecology.

The survey begins with examination of quantitative descriptions of vegetation, problems of sampling, and compar-

ison of results of different groups of observations. It then moves on to tests of association between species and theoretical approaches to the ecological concept of associations. Correlation of vegetation with habitat factors is treated according to different combinations of quantitative and qualitative data relating to plant and environmental factors. Floristic composition, species-area relationships, and other features of plant communities are considered in a separate chapter on quantitative aspects of phytosociology. The final chapter is a well-presented summary of the author's views on the quantitative approach to plant ecology, including interesting observations on the meaning of pattern as elucidated in quantitative studies.

All ecologists are more or less concerned with the quantitative approach as it is discussed in this book. Many will find the book a useful guide to recent progress and a thought-provoking critique of major problems in quantitative aspects of plant ecology.

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Methods of Biochemical Analysis. vols. 5 and 6. David Glick, Ed. Interscience, New York, 1957; 1958. ix + 502 pp. $9.50; ix + 358 pp. $8.50.

This series constitutes a valuable contribution to biochemistry. Its objectives are to discuss the recent developments in biochemical methodology, to evaluate critically the available procedures, and to give detailed instructions for the method or methods of choice. For the most part, the editors and the contributors should be commended for their success in carrying out these objectives.

These two volumes are worthy additions to this series. Volume 5 should be of particular value to biochemists interested in the microanalysis of metallic ions, since it contains a chapter on "The micro determination of cobalt in biological materials," with emphasis on the spectrographic procedures; an excellent review of "Activation analysis and its application in biochemistry"; and a discussion of "Contamination in trace element analysis and its control." This volume also contains chapters on "Assay methods for cholinesterases," "Biological standards in biochemical analysis," "α-Keto acid determinations," "Chemical determination of estrogens in human urine," and "Infrared analysis of vitamins, hormones and coenzymes." Volume 6 should be of particular interest to purine and pyrimidine biochemists, since it includes chapters on the "Chemical determination of nucleic acids," "Microbiological assay of nucleic acids and their derivatives," and "New methods for purification and separation of purines." The other chapters are "Determination of formaldehyde and serine in biological systems," "Assay of serotonin and related metabolites," "Determination of transaminase," "Determination of thiamine," "Glycolipid Determination," "Determination of hexosamines," and "Electrophoresis in density gradients combined with *p*H and/or conductivity gradients."

The reviews are logically organized, well documented, and clearly written. These two volumes should be valuable to the research biochemist as reference books. As an aid to their use, each volume has a subject index, an author index, and a cumulative title index. However, no cumulative subject index has been included.

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New Books

Angler's Guide to the Salt Water Game Fishes, Atlantic and Pacific. Edward C. Migdalski. Rondla, New York, 1958. 516 pp. $7.50.

Atlas of Microorganisms, The Penicillia. Shigeo Abe. Kin-Ichiro Sakaguchi, Ed. Kanehara Shuppan Co., Tokyo, Japan, 1957 (order from Matthews Book Co., St. Louis 4, Mo.). 336 pp. $20.

Brave New World Revisited. Aldous Huxley. Harper, New York, 1958. 147 pp. $3.

Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. Tortricidae, Olethreutidae, Noctuidae. J. F. Gates Clarke. British Museum (Natural History), London, 1958. 600 pp. £6.

Catalysis. vol. 6, *Alkylation, Isomerization, Polymerization, Cracking and Hydroreforming.* Paul H. Emmett, Ed. Reinhold, New York; Chapman & Hall, London, 1958. 712 pp. $19.50. Contents: "Catalytic alkylation of paraffins with olefins" (Robert M. Kennedy), "Catalytic isomerization of hydrocarbons" (F. E. Condon), "Mechanisms of polymer formation and decomposition" (R. Simha and Leo A. Wall), "Polymerization of olefins" (A. G. Oblad, G. A. Mills, Heinz Heinemann), "Catalytic cracking" (Hervey H. Voge), and "Catalytic reforming of pure hydrocarbons and petroleum naphthas" F. G. Ciapetts, R. M. Dobres, R. W. Baker).

The Chemical Prevention of Cardiac Necroses. Hans Selye. Ronald, New York, 1958. 244 pp. $7.50.

Collecting, Preserving and Studying Insects. Harold Oldroyd. Macmillan, New York, 1958. 327 pp. $5.

Electronic Aviation Engineering. Peter C. Sandretto. International Telephone and Telegraph Corp., New York, 1958. 781 pp. $9.50.

Elementary Matrix Algebra. Franz E. Hohn. Macmillan, New York, 1958. 316 pp. $10.

Emergency War Surgery. U.S. Armed Forces issue of *NATO Handbook* prepared for use by the medical services of NATO nations. U.S. Department of Defense, Washington, 1958 (order from Supt. of Documents, GPO, Washington 25). 422 pp. $2.25. This handbook was developed by a committee of three surgical consultants representing the military medical services of France, the United Kingdom, and the United States, assisted by observers and the written recommendations from other NATO countries. The material used was obtained from authors and publications of many NATO countries.

Experiments in General Chemistry. Joseph B. Nordmann and Ernest S. Kuljian. Burgess, Minneapolis, Minn., 1958. 162 pp.

The Fossil Book. A record of prehistoric life. Carroll Lane Fenton and Mildred Adams Fenton. Doubleday, New York, 1958. 495 pp. $12.50. *The Fossil Book* relates the story of life during the past 2 billion years. It is a collector's guide that tells what fossils are and where to find them.

Geology of the Great Lakes. Jack L. Hough. Univ. of Illinois Press, Urbana, 1958. 331 pp. $8.50.

The Health of a Nation. Harvey W. Wiley and the fight for pure food. Univ. of Chicago Press, Chicago, Ill., 1958. 342 pp. $6.

The Illustrated Library of the Natural Sciences. vols. 1–4. Simon and Schuster, New York, 1958. 3042 pp. $19.95 until 25 Dec.; $25. This four-volume survey of the world of nature—over a million words and more than 3000 pictures—covers every field of natural science. From the first entry, Aardvark, to the last, Zebra, the alphabetically arranged volumes provide entertainment and information. Among the outstanding contributors are Marston Bates, William Beebe, Alfred Emerson, Homer E. Newell, Jr., and George Gaylord Simpson.

Immunology and Development. Mac V. Edds, Jr. Univ. of Chicago Press, Chicago, Ill., 1958. 69 pp. $2.50.

Internal Conversion Coefficients. M. E. Rose. North-Holland, Amsterdam; Interscience, New York, 1958. 182 pp. $6.25.

Introduction to the Theory of Sound Transmission. With application to the ocean. C. B. Officer. McGraw-Hill, New York, 1958. 292 pp. $10.

Linear Operators. pt. I, *General Theory.* Nelson Dunford and Jacob T. Schwartz. Interscience, New York, 1958. 872 pp. $23.

Living Birds of the World. E. Thomas Gilliard. Doubleday, New York, 1958. 400 pp. $12.50. Gilliard, associate curator of birds at the American Museum of Natural History, discusses all the known bird families and subfamilies and almost 1500 species.

Reports

X-ray Visualization and Analysis of Multicomponent Subjects

Abstract. The information carried by x-rays showing the distribution of each material of which a subject is assumed to be composed is distributed on separate films by means of a controlled variation in composition of the scanning radiation. The beam is modulated, for example, by simultaneous motion of several wedges. The method is useful in quantitative x-ray analysis and as a system for making radiographs predominantly sensitive to one material in the subject.

The usual radiographic methods discard information by lumping the effects of the subject on a number of x-ray wavelengths into a single monochrome display (black and white radiograph). Some additional information about subject absorption and its rate of change with wavelength can be presented to the eye in the form of a colored image or print that is formed from "separation negatives" made by taking two or three radiographs with differing incident x-ray wavelength distributions (*1*). A possibility exists for the study of a many-component system in which each component is separately mapped for distribution density, the survey of all components taking place simultaneously.

This method can most conveniently be understood as a generalization of a simple scheme. Suppose a monochromatic x-ray beam traverses a wedge of some material and then falls upon an intensity detector whose output controls the wedge position in such a way as to bring the detected intensity to a preset value. Then if a sample of this same material is also inserted in the beam, the wedge will move out in such a way as to leave the total amount of this material in the beam fixed. The distance the wedge moves out is proportional to the amount of the material introduced. The motion can be recorded on a film as a variable darkening, and scanning the subject thus provides a radiograph showing the over-all distribution of this material. The same thing is true if there are j wavelengths, each maintained at constant intensity, and j materials. Each wedge will then move independently of the rest to indicate the amount of its material in the subject. The motion of all the other wedges cancels fluctuation in amount of substances other than the one of interest. There result j monochrome images for later individual study, each depicting the distribution of one material. This can be considered either as a method of quantitative analysis, or as a method of radiography.

It is possible to prove that under equilibrium conditions there is a unique endpoint. In the proof one also finds the condition that substances be considered distinct and thus distinguishable. In Fig. 1 is shown a schematic representation of the system. Each of the j wavelengths m is assumed to be attenuated to a fixed intensity fraction k by traversing the subject and wedges. If μ_{nm} is the absorption coefficient of the nth material for the mth wavelength, then there is one equation for each λ that expresses the outgoing intensity in terms of the traversed thickness of each of the materials:

$$\sum_{n=1}^{j} -\mu_{nm}\, t_n = \log k_m$$

Thus there are j simultaneous algebraic equations in the thicknesses of the j materials (wedge plus wedge-material in the subject). The quotient of two determinants gives the value of t traversed in any one material. One of the determinants is made up of the μ's and the other is made up of the μ's and k's, and thus each t is a number (a constant). This shows that, at equilibrium, the total amount of each material in the beam is individually constant. Thus, for example, if 1 g/cm² of a material is present in the unknown, then *that* wedge will move out by an amount exactly equivalent to 1 g/cm².

The previous is true if the coefficients of t are such that no two equations are "derived equations." This gives the precise definition with which the term "distinct materials" is here used. The observed laws of x-ray absorption are such that different elements tend to be distinct. Essentially two materials are distinct if their absorption curves, as a function of wavelength, do not have pairs of proportional ordinates in the range of wavelengths used.

The greater the differences in the way absorption varies between the materials, the greater are the unbalance signals. Thus, for maximum sensitivity, it is advantageous to work around absorption discontinuities or edges.

The control signal to any one wedge will vanish at equilibrium if it is any linear combination of the error signals from the detectors. Circuitry that worked in a two-wedge experiment will be cited, but the best general system for good transient response has not yet been fully investigated. Though it does not assure that a corrective signal will be applied only to the wedge that is out of position, it does seem desirable that the signal to any one wedge be made of a sum of the phototube signals, each weighted by the μ of that wedge for the λ in question. This directs corrective effort at a given λ predominantly to the material which most affects this λ, rather than encouraging large excursions by the other wedges.

The j wavelengths can either follow

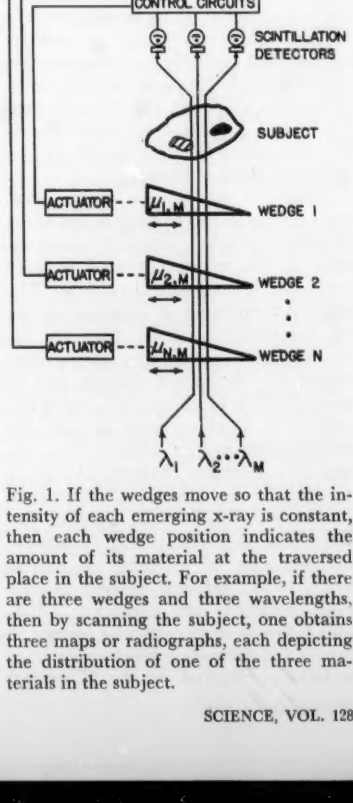

Fig. 1. If the wedges move so that the intensity of each emerging x-ray is constant, then each wedge position indicates the amount of its material at the traversed place in the subject. For example, if there are three wedges and three wavelengths, then by scanning the subject, one obtains three maps or radiographs, each depicting the distribution of one of the three materials in the subject.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

each other in succession onto one detector or they can all act simultaneously onto j detectors. The beams must all traverse the same region of the subject and so, because of this and drift considerations, a single detector is felt to be best even though some sort of memory or gating circuit is then required.

A piece of equipment already under construction in Sweden for a related operation was modified as a joint effort to test this new principle. The experimental arrangement and some results have been given (*1*). In this case the scheme was adapted to the detection of iodine (either the quantitative analysis of that normally present in human beings, or the sensitive mapping of a standard x-ray contrast medium). The two wedges were made of iodine and of plastic, the latter being similar to soft tissue. The monochromatic wavelengths were supplied alternately by a pair of rotating secondary emitters (fluorescent radiation). These wavelengths were chosen to fall just on opposite sides of the iodine k absorption edge for maximum sensitivity.

The position of the plastic wedge was automatically adjusted through suitable gating circuits to bring the longer wavelength always to a preset intensity value. The a-c component in the detector signal, as the two wavelengths alternated, was brought to zero by control of the iodine wedge position. This then brought the intensity of the shorter wavelength also to the preset value. The two wedges steadily hunted, at slightly different frequencies, in a small range about their proper positions, as hoped. Wedge position was used to control the frequency of a flashing light which blackened a film during the scanning process. Thus the iodine distribution was mapped.

Jacobson independently reported some observations with the unit (*2*) and noted that fat does not seem to act like water. Thus three wedges would be more suitable. He noted that 1 g of fat per square centimeter acted like 0.5 mg of iodine per square centimeter.

Nonuniform irradiation of the subject —for example, by applying most of the dose around the edges of the structure— can reduce the total dose to a subject in producing a given image quality; but constant-output intensity systems such as the present one tend to minimize dose (*3*). Another property of such systems is that they can be compensated against source-intensity fluctuations with an auxiliary detector and difference amplifier, rather than with a ratio detector.

From dose considerations this procedure is most practical in human beings for the relatively heavy elements because the lighter ones demand "soft" highly absorbed wavelengths, if use is to be made of absorption edges. Possibly heavier elements should be used in contrast media for this reason (at least for use in retrograde application). A similar system may have application in the ultraviolet, and the optical analog is sometimes a convenient guide to thought (*4*).

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References and Notes

1. For discussion of this see B. Jacobson and R. S. Mackay, *Advances in Biological and Medical Physics*, J. H. Lawrence and C. A. Tobias, Eds., (Academic Press, New York, 1958), vol. 6, pp. 201–261.
2. B. Jacobson, paper presented at the International Conference on Medical Electronics, Paris, 28 June 1958.
3. R. S. Mackay, *Brit. J. Radiol.* 31, 642 (1958).
4. This method was conceived while I was on leave from the University of California as a Guggenheim fellow.

31 July 1958

Geochemical Scavenging of Strontium

Abstract. Crandallite, an abundant mineral belonging to the alunite structure type, is a geochemical host for ordinary strontium in the soil profile and the deeper ground-water circulation. It may be useful in the scavenging or storage of the radioisotopes of strontium and certain other elements.

The chemical action by ground waters of the deeper meteoric circulation and of the zone of weathering on pre-existing rocks results in the formation of secondary minerals appropriate to the new environmental conditions. Certain of the minerals of the original rock that are resistant to chemical attack also may accumulate as residual deposits, and other material may be yielded in soluble form and ultimately removed in the surface drainage.

Elements present in trace amounts in the original rock, if not removed in solution, may be concentrated and redeposited locally by the ground waters either as specific compounds or in solid solution in variable amounts in certain other more abundant minerals. Adsorption and cation-exchange mechanisms also may be operative. The natural geochemical and crystallochemical behavior in the ground-water circulation of strontium and of other trace elements of interest in connection with radioactive wastes and fallout may be informative in relation to the artificial storage or scavenging of the radioisotopes of these elements in ways that involve geological environments and materials.

With regard to strontium, the hitherto known host minerals for this element are operative chiefly in the magmatic and sedimentary cycles. A few, such as members of the aragonite and barite structure types, are of consequence in the deeper ground-water circulation. None of these minerals normally form in, or are stable in, the soil profile, where they could act as hosts, and it has been generally believed that strontium released during weathering is retained in soluble form in the soil waters.

Recently, it has been established (*1*) that minerals of the alunite structure type also are specific geochemical hosts for strontium. Crandallite, $CaAl_3(PO_4)_2(OH)_5H_2O$, is of particular interest. In crandallite deposits of the deeper circulation, such as those of the Fairfield, Utah, type, where descending phosphatic solutions derived from marine phosphate-rock formations have reacted with argillaceous limestone, the crandallite is enriched in strontium. Crandallite develops analogously in the soil profile during the weathering of phosphatic limestone and marine phosphorites. The occurrence of crandallite in this way has been recognized only in recent years (*2*), and little is known of the extent of such occurrences over the world. The surficial crandallite deposits of one area in the Florida Gulf coastal region have been estimated at upwards of 800 million tons. The Senegal deposits are larger and have been mined for their phosphate content, but the resources are not known. Although the available data are very scant, the Senegal crandallite contains up to at least 0.50 percent SrO by weight, and it appears to be enriched in Sr over the phosphate rock from which it was derived.

The formation of crandallite by natural processes in the zone of weathering is restricted to areas of favorable bedrock and ground-water composition, and the mineral is not a constituent of soils in general. However, since it is stable under neutral and alkaline conditions, it probably would remain unchanged, without further control of the soil pH, if added to most soils. The availability of the mineral and its known ability to house strontium by both crystallization and cation-exchange mechanisms suggests that it possibly may be of interest as a scavenger in arable soils and as a vehicle for the storage of radioactive wastes. Knowledge of areas in which crandallite is a natural constituent of the soil profile would be pertinent to any general study of the distribution of strontium between the hydrosphere, the lithosphere, and vegetation.

In the alunite structure type (*3*), the monovalent and divalent ions are held in relatively open 12-coordinated positions that are very tolerant with regard to both the size and the valence of the contained

ions. These ions include Sr, Pb, Ba, Ca, Cs, K, Na, NH_4, Ag, and Ce. Among them are several elements of interest with respect to radioactive wastes and fallout. The alunite type of structure is suited to the housing of relatively large cations, and it is primarily this factor that accounts for the observed preferential substitution of Sr for Ca in crandallite over coexisting Ca minerals, such as calcite and apatite, in which the cation coordination number is smaller.

Crandallite readily exchanges Ca for dissolved Sr. Since the 12-coordinated cation sites are not interconnected, as are the sites in cation-exchangers of the channeled zeolitic and layered phyllosilicate types, the exchange is limited to surface positions. For example, a freshly prepared gel of synthetic crandallite, a gel coarsened to microscopic crystals by hydrothermal treatment at 250°C, and crude Senegal crandallite rock crushed to pass 200 mesh were placed in 0.02M solutions of strontium nitrate. The amounts of solution and of solid phase were adjusted so that each contained the same number of Ca and Sr ions. In neutral and weakly alkaline solutions the percentages of exchange between Ca and Sr in the three preparations were roughly 31, 18, and 4 percent, respectively. Below *p*H 6.5 the amount of exchange decreases markedly. Natural crude Senegal crandallite rock was found to have an appreciable acidity-reducing capacity, presumably due to admixed basic aluminum phosphates and silicates. The reverse exchange, that of Ca for Sr in crystalline $SrAl_3(PO_4)_2(OH)_5H_2O$, was found to be quite small, in line with the relative solubilities and ionic adsorptive powers of Ca and Sr in general.

The mineral apatite, $Ca_5(PO_4)_3(OH)$, also takes up Sr in solid solution and has an appreciable adsorptive capacity for Sr in neutral solutions. The known reserves of natural phosphate rock (apatite) have been estimated at upwards of 40 billion tons suitable for conventional commercial applications. Apatite, however, is soluble in alkaline and carbonated ground waters and, unlike crandallite, is removed from the soil profile. Admixture of this mineral with crandallite as a top dressing might be useful both in controlling *p*H and in transiently affording ordinary Sr to the ground water. Natural phosphate rock contains roughly 0.01 to 0.20 per cent SrO by weight. The Sr and the Ca afforded by dissolution may act as a diluent for Sr^{90} available to plant life either directly from the ground water or by biochemical decomposition of the scavenger mineral.

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References

1. C. Frondel, *Bull. Geol. Soc. Am.*, in press.
2. L. Capdecomme, "Aluminous phosphates of the region of Thies, Senegal," *Compt. rend.* 235, 187 (1952); *Congr. géol. intern. Compt. rend. 19th Session, Algiers, 1952* (1953), pt. 11, pp. 103–117; Z. S. Altschuler, E. B. Jaffe, F. Cuttitta, "The Aluminous Phosphate Zone of the Bone Valley Formation, Florida, and Its Uranium Deposits," *U.S. Geol. Survey Profess. Paper No. 300* (1956), pp. 495–504.
3. S. B. Hendricks, "The crystal structure of alunite and the jarosites," *Am. Mineralogist* 22, 773 (1937).

20 August 1958

Rate of Swelling of Collagen

Abstract. The osmotic pressure gradient across the collagen solid matrix-solution interface forces the solid to imbibe fluid and thereby increases its volume. Concurrently, the decrease in entropy of the solid matrix produces a force which tends to resist any further increase in volume. The instantaneous velocity at which the swelling takes place is related to the difference between the osmotic and entropic forces. Finally, an explicit relationship is obtained between volume and time.

Swelling is an important property of polymers and is an outstanding characteristic of collagen. The two types which can be distinguished are (i) osmotic and (ii) lyotropic (bond scission). In type i the matrix imbibes fluid due to an osmotic pressure gradient across its solid-solvent interface; the restraining pressure of the matrix finally equals the osmotic pressure so that an equilibrium is attained. Certain fluids react with the matrix so as to loosen bonds (type ii); the swelling then proceeds to a greater extent because the restraining pressure of the matrix is reduced.

In a polyelectrolyte such as collagen, the equilibrium swelling volume depends upon the *p*H of the solvent (*1*). A minimum of swelling occurs near the isoelectric point, whereas pronounced swelling develops in the acid and alkaline *p*H regions. Acetic acid, particularly, is effective in both the solubilization and swelling of collagen.

Studies of types i and ii have been done particularly from measurements based on equilibrium swelling. Little attention has been given to the rate of the swelling process. The purpose of this report is to describe a rate mechanism of the swelling process which embodies both osmotic and lyotropic attributes of the system, collagen–acetic acid–water.

The isoelectric point of limed hide powder collagen is about *p*H 5.5. When this is placed in water, hydrogen ions leave the matrix to a certain extent and dissolve in the interstitial water phase. The matrix becomes an anion and its counter-ion is trapped inside. When it is placed in dilute acetic acid at *p*H 2 to 3, hydrogen ions are forced on to the matrix which thereby becomes a cation; its counter-ion again is trapped inside. This description of type i may be formulated to give the pressure inside the matrix which produces swelling—that is,

$$\pi = nRT/V = A/V,$$

where π is the osmotic pressure of the interstitial fluid phase of volume V for n moles of ions at a temperature T. Since the gas constant (R), n, and T are independent of the volume they may be combined to form A. The increased volume of the matrix forces random chains of collagen to become more uniformly aligned, with a subsequent decrease in their entropy. This reduction in entropy causes an increase in the matrix pressure which resists further volume increases. The retarding pressure of the matrix may be considered to be linearly related to its volume—that is, $P = \alpha V$, where α is a constant characteristic of the matrix restraining ability. The rate of change of volume with time can now be stated as being proportional to the difference in osmotic pressure π and the restraining pressure P in Eq. 1.

$$dV/dt = k(\pi - P) = k(A/V - \alpha V) \quad (1)$$

At swelling equilibrium Eq. 1 equals zero. Thus, Eq. 2 shows the dependence

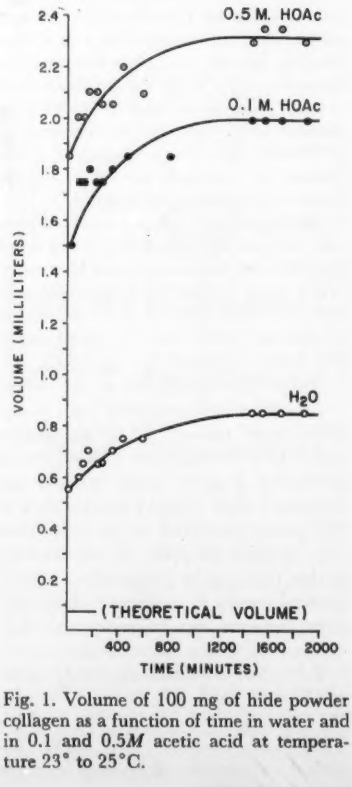

Fig. 1. Volume of 100 mg of hide powder collagen as a function of time in water and in 0.1 and 0.5*M* acetic acid at temperature 23° to 25°C.

Table 1. Values of constants.

Constant	Water	Acetic acid	
		0.1*M*	0.5*M*
V_0^2	0.29	2.17	3.30
V_∞^2	0.72	4.00	5.42
$2\alpha k$	0.0018	0.0025	0.0025

of the equilibrium volume V_∞ on the parameters A and α.

$$V_\infty = (A/\alpha)^{1/2} \quad (2)$$

When Eq. 1 is integrated and solved explicitly for V^2, Eq. 3 is obtained.

$$V^2 = V_\infty^2 - (V_\infty^2 - V_0^2)e^{-2\alpha kt} \quad (3)$$

If measurements of V^2 are made at sufficiently short times so that $e^{-2\alpha kt}$ can be approximated by $(1 - 2\alpha kt)$, then Eq. 4 is formed.

$$V^2 = V_0^2 + (V_\infty^2 - V_0^2)2\alpha kt \quad (4)$$

The following is an application of this theory to the swelling data of collagen in water and dilute acetic acid (0.1 to 0.5*M*).

One hundred milligram samples of hide powder collagen (*2*) were placed in 15-ml graduated centrifuge tubes. Then, 10 ml of water or dilute acetic acid was added. The tube was shaken for 2 to 3 minutes and spun at 3000 rev/min for 10 minutes to pack the swollen fibers. The volume of the sediment was then read to the nearest 0.1 ml, and the mixture was shaken again for 2 to 3 minutes. It was allowed to settle until the next volume was read. This process was repeated at 30-minute intervals during the initial stages of swelling but later at longer intervals. Water and aqueous solutions of acetic acid (0.1 to 0.5*M*) were used to swell collagen at temperatures of 23° to 25°C. The force and time at which the samples were centrifuged determines the volume of the sediment. However, both of these factors were constant throughout the study.

In Fig. 1 the volume of collagen is shown as a function of time for swelling in water and in 0.1 and 0.5*M* acetic acid at 23° to 25°C. The experimental data were plotted according to Eqs. 4 and 5 and were in conformity with the theoretical requirements except at zero time. The latter points always deviated from theoretical. The interpretation is given that collagen swells in two steps. Initially, the fibers imbibe solvent at a rapid rate until they reach the volume V_0. Thereafter, they swell from V_0 to V_∞ by the proposed osmotic mechanism. Table 1 shows the values of the constants determined for the swelling of collagen in water and dilute acetic acid. The influence of solvent on V_∞ is probably due to a reduction in α by the more active acetic acid. Since $2\alpha k$ showed only slight alteration with solvent, then, the specific rate constant k must have been elevated in acetic acid in comparison to water. V_0 presumably is also a measure of collagen solvation and its swelling by a particular solvent. In going from water to 0.5*M* acetic acid, the greater V_0 could be due to a discharge of carboxylate-basic salt-links. The lower *p*H of the acetic acid solutions would free the ionic attraction of chains previously bound by such bridges.

An analysis of the sorption of water by rubber (*3*) similarly was based on the osmotic pressure gradient of a solvent in the matrix as presented by Testor. If V_∞ were considerably greater than V_0, the rubber swelling equation would be identical with that for collagen. It appears then that processes other than Fick diffusion mechanisms determine the swelling and sorption in some types of polymers.

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References

1. K. Gustavson, *The Chemistry and Reactivity of Collagen* (Academic Press, New York, 1956), p. 156.
2. F. F. Marshall, Ridgway, Pa.
3. D. A. Testor, *J. Polymer Sci.* 19, 535 (1956).

16 July 1958

Measurement of Precipitin Reactions in the Millimicrogram Protein-Nitrogen Range

Abstract. Exploitation of newer instrumentation and a dye-binding method for protein measurement made possible reduction in volume down to 1/1000 that commonly used, with no greater error. The procedure was tested at two levels, 1- and 10-μl volumes, with human gamma globulin and rabbit antiserum. Of the dyes tested, bromsulfalein proved best for the protein estimation.

The value of a method which would require a few drops to less than one drop of blood for replicate measurements of the precipitin reaction, particularly in pediatric practice and for studies with small laboratory animals, is obvious. Such a method should also be applicable to the microsamples involved in certain quantitative histo- and cytochemical studies. Exploitation of newer instrumentation (*1*) and a dye-binding method for determination of protein in millimicrogram amounts (*2*) made it feasible to modify and scale down the commonly used procedure, involving the so-called "micro" Kjeldahl analysis of the antigen-antibody precipitate (*3*), to the level required. With the method herein described, interaction of 10 μl of antigen solution with 10 μl of antiserum provides over 1 ml of colored solution for final measurement. Since this measurement can be carried out on less than 10 μl [for example, with the Beckman DU spectrophotometer adapted to microcuvettes (*1*)], it should be possible to use volumes of antigen and antiserum down to 0.1 μl, although in this study volumes down to only 1 μl were used. A comparison of four acid dyes previously employed for protein measurement or dye-protein binding studies (*2, 4*) was included in this investigation (*5*).

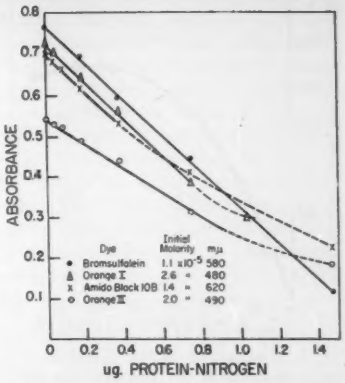

Fig. 1. Dye-binding of bovine serum albumin in 1 mg per 100 ml of bromsulfalein (Hynson, Westcott, and Dunning) and other dyes (Hartman-Leddon), at *p*H 2.

For the dye preparations used, maximal absorbance was given at the wavelengths shown in Fig. 1, and maximal binding to bovine serum albumin (Armour, fraction V) was obtained at *p*H 2 in 0.1*M* citric acid-sec phosphate buffer. Readily available albumin was used, since the dye-binding is comparatively nonspecific. The data in Fig. 1 were obtained by mixing 50 μl of buffered dye solution (12 mg/100 ml) with 20 μl of albumin solution and letting the mixture stand for 15 minutes, centrifuging it at 3000*g* for 5 minutes, adding 60 μl of the clear supernatant to 0.5 ml of distilled water, and measuring the absorbance. A blank was prepared by replacing the albumin solution with water. The dye concentrations listed in Fig. 1 are those of the blank solutions. Commercial dye preparations were used without further purification, since this sufficed for the practical purposes at hand. Dye-binding was linear at low albumin concentrations in all cases, but only bromsulfalein maintained linearity over the whole range tested; in fact, under the conditions of tissue analysis, its linearity extends to 2.25 μg of protein-nitrogen, with a reduced slope (*2*). Although both Amido

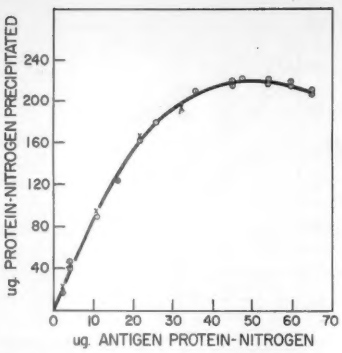

Fig. 2. Comparison of the Kjeldahl (×) and bromsulfalein (⊙) methods for measuring precipitate as a function of quantity of antigen (human gamma globulin) in the precipitin reaction with rabbit antiserum. Values from the Bromsulfalein method were multiplied by 100 to make them comparable to the Kjeldahl data.

Black 10B and Orange I exhibited approximately the same change in absorbance per unit protein over their linear ranges as bromsulfalein, their linearity was confined to a short range, making bromsulfalein preferable for analytical work.

The agreement between the Kjeldahl method for determining the amount of antigen-antibody precipitate and the bromsulfalein method is apparent in Fig. 2. The procedure for the latter method, which follows, differed from that for the former in the use of volumes 100 times smaller. Ten microliters of rabbit antiserum to human gamma globulin was placed in each of a series of glass tubes 27 mm long and of 4-mm inner diameter. Ten microliters of the gamma globulin in 0.9-percent sodium chloride (10 dilutions were used over the range 4.3 to 47 mμg/μl) was added to each tube and mixed. Each concentration of globulin was set up in triplicate, and blanks were included in which 0.9-percent sodium chloride was substituted for the globulin solution. The tubes were held at 37°C for 1 hour and transferred to a refrigerator for 7 days' storage at 2°C, during which time the precipitates were carefully resuspended once each day by gently tapping the tubes so as to prevent precipitate from lodging on the walls above the liquid. The tubes were then centrifuged at 2°C for 1 hour at 3800*g* in a microcentrifuge (*6*). The supernatant fluid was withdrawn by a micropipette and discarded, 15 μl of cold 0.9-percent sodium chloride was added, and the precipitate was resuspended by "buzzing"—that is, vibrating the vessel by touching its side near the bottom to a flattened nail spinning in the chuck of a high-speed hand drill—and then recentrifuged as before. A second washing of the precipitate was carried out in the same manner, and then the precipitate was used for protein-nitrogen measurement. A check of the procedure revealed that a third washing was without influence.

The "micro" Kjeldahl analysis of protein-nitrogen was conducted in the standard fashion. The dye procedure was carried out as follows. The precipitates in the tubes were dried in a vacuum desiccator. The protein was dissolved in 20 μl of 1*N* sodium hydroxide by mixing, letting the mixture stand for 30 minutes, and again mixing. Fifty microliters of bromsulfalein reagent (1 ml of 5-percent dye plus 100 ml of 1*N* hydrochloric acid plus 50 ml of 1*M* citric acid plus distilled water to a final volume of 250 ml) was added and mixed. The tubes were centrifuged at room temperature for 5 minutes at 3800*g*. Sixty microliters of supernatant was withdrawn and added to 1 ml of 0.1*N* sodium hydroxide. After mixing, the absorbance was measured at 580 mμ, and the protein-nitrogen was calculated as described earlier (*2*).

To test the precision of the dye method, the entire procedure was repeated nine times; a single gamma globulin solution was used (43 mμg/μl), and all volumes were reduced to 1/10 the volumes used in the earlier tests—that is, 1 μl of antiserum and 1 μl of gamma globulin were used. Tubes 27 mm long and of 2.5-mm inner diameter were employed. A mean value of 233 mμg of protein (standard deviation and error, 10.4 and 4.7 percent, respectively) was obtained.

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References and Notes

1. D. Glick, *J. Histochem. and Cytochem.* 5, 539 (1957).
2. S. N. Nayyar and D. Glick, *ibid.* 2, 282 (1954).
3. R. Markham, *Biochem. J.* 36, 790 (1942); E. A. Kabat and M. M. Mayer, *Experimental Immunochemistry* (Thomas, Springfield, Ill., 1948).
4. C. M. Plum, L. Hermansen, I. Peterson, *Scand. J. Clin. & Lab. Invest. Suppl.* 18 (1954); D. B. Wetlaufer and M. A. Stahmann, *J. Am. Chem. Soc.* 80, 1493 (1958); E. Fredericq, *Bull. soc. chim. Belges* 65, 644 (1956).
5. This study is No. LV in the Studies in Histochemistry series; it was supported by research grants from the U.S. Public Health Service [RG3911, H2028, H2085], the Louis W. and Maud Hill Family Foundation, and the American Heart Association.
6. The microcentrifuge used in these experiments was provided by the Microchemical Specialties Co., Berkeley, Calif.

4 August 1958

Hypothalamic Lesions and Sexual Behavior in the Female Rat

Abstract. This study reports selective effects on the mating pattern of the female rat of partial destruction of the hypothalamus. Independent neural control of the ovarian cycle and of the mating response are demonstrated. Both depressed and augmented female sexual activity are reported.

Several studies have suggested the importance of the hypothalamus in the regulation and control of sexual behavior (*1–5*). Most previous work reports diminution or abolition of mating behavior following interference with hypothalamic structures. The effect is usually ascribed to disturbances in the production of the gonadotrophins.

This study (*6*) indicates that sexual behavior is differentially affected by small lesions in discrete hypothalamic regions; some lesions augment sexual activity. Moreover, the effect is not wholly hormonal; central neural mechanisms are immediately involved.

Forty-five female rats surviving all operative procedures were divided among two major groups, spayed and nonspayed. Each group consisted of four subgroups: animals with lesions in the anterior, central, and posterior hypothalamus (designated "operated" subgroups), and animals without lesions. Lesions were stereotactically placed 1 mm lateral to the midline and 1 mm dorsal to the ventral surface of the brain, and at Krieg coordinates 58 and 59 (anterior), 56 and 57 (central), and 54 and 55 (posterior). Direct current of 1.5 to 2.0 ma, lasting for 10 to 15 seconds, was used to make the lesions. Locations of lesions were subsequently verified histologically.

Estrus was induced in the spayed rats once weekly for 3 weeks by treatment with diethylstilbestrol and progesterone in sequence (*7*).

Females were tested for mating responses with male rats preselected as vigorous maters. Tests were conducted daily for 10 minutes for each female. Tests eliciting no male response were repeated the same day with another test male. All tests were conducted in transparent cages, which served as the male's home cage.

Female mating behavior was defined in terms of the characteristic stereotyped lordosis response, a concave arching of the back upon approach and mounting by the male. Lordosis frequencies were tallied and appear as "responses" in Table 1.

Daily vaginal smears were taken. Smears were dichotomized into diestrus (leukocytes only) and estrus (presence of epithelial cells). This unconventional,

Table 1. Comparison of vaginal smear and mating behavior of spayed and nonspayed, operated, and unoperated female rats. A.H.L., anterior hypothalamic lesions; C.H.L., central hypothalamic lesions; P.H.L., posterior hypothalamic lesions.

Item	(1) No.	(2) Total days tested	(3) Mean days diestrus	(4) Mean days mating, diestrus	(5) No. responding	(6) Mean responses in diestrus	(7) Mean days, estrus	(8) Mean days mating, estrus	(9) No. responding	(10) Mean responses in estrus
					Spayed					
Control	8	195			1				8	
Mean			4.4	0.25		1.0	20.0	9.7		7.8
Range		20–29	2–9	0–2		0–8	16–23	3–13		1.6–15.3
A.H.L.	4	48			1				4	
Mean			2.8	0.25		2.0	9.3	1.5		27.3
Range		8–14	2–4	0–1		0–8	6–12	1–3		21–41
C.H.L.	3	40			1				0	
Mean			3.2	0.33		5.6	9.3	0		0.0
Range		12–14	3–6	0–1		0–17	7–11	0		0
P.H.L.	2	28			2				2	
Mean			4.5	1.5		21.5	9.5	1.5		19.0
Range		14–14	6–9	1–2		11–32	8–11	1–2		16–22
					Normal					
Control	10	139			1				9	
Mean			6.4	0.1		0.7	7.9	1.6		12.3
Range		9–18	1–11	0–1		0–7	5–12	0–3		0–24.5
A.H.L.	5	105			5				5	
Mean			13.4	1.2		12.8	7.6	1.2		12.5
Range		21–21	11–16	1–2		1–24	5–10	1–2		3–21
C.H.L.	6	125			1				0	
Mean			10.8	0.17		4.1	10.0	0		0.0
Range		20–21	0–18	0–1		0–25	3–21	0		0
P.H.L.	4	96			3				4	
Mean			14.8	3.3		14.5	9.3	4		14.7
Range		21–25	10–19	0–5		0–23	6–15	1–9		4–21.5

but conservative, classification was adopted to reduce ambiguity in interpretation of vaginal stages.

There was a tendency for spayed, hormone-treated animals without lesions to spend less time in diestrus (column 3). They resembled the normal control animals, however, in failing to mate appreciably during diestrus (column 5). Because the spayed animals spent more time in estrus, they also mated more frequently during estrus, but average responses per test (column 10) were less for the spayed than for the normal animals. All spayed subgroups had a greater percentage of days in estrus than their nonspayed counterparts, because of the exogenous hormones.

Although central hypothalamic lesions in the region of the posterior border of the optic chiasm diminished or abolished the female mating response in both groups, there was no marked tendency to produce constant vaginal cornification ("estrus"), as was found in other studies (*2, 4*). Of the nine animals with central hypothalamic lesions, only two ever mated. Both of these responses occurred while the animals were clearly in a diestrus vaginal condition. The mean response frequency for each of these cases was higher than it was for the unoperated animals in diestrus but lower than it was for the unoperated animals in estrus. None of these nine animals ever mated in estrus.

Posterior hypothalamic damage in the pre-mammillary region yields a very different result. Five of the six animals with this lesion mated in diestrus. The average response frequency of animals in this condition exceeded that of the unoperated animals in estrus, and equalled or excelled the rate for the same animals during estrus. All six animals mated at least once in estrus, and at a mean rate greater than the control rate.

Anterior hypothalamic lesions in the preoptic area gave effects on mating behavior similar to those of the P.H.L. group. The diestrus mating responses of the spayed groups are the only exception. The figures for the latter animals resemble more the performance figures for unoperated animals. Estrus mating for spayed and nonspayed animals with anterior hypothalamic lesions was normal or better. Diestrus responses for nonspayed animals are augmented.

The results indicate a more specific localization of function within the hypothalamus than was previously suspected. The decrement in female mating in the group with central hypothalamic lesions suggests interference with a neural mechanism necessary to sexual receptivity. That this effect is independent of hormonal factors is clear from the data of the groups receiving exogenous hormones. The absence of persistent vaginal cornification in our study substantiates this view. Our lesions were considerably smaller than those used in most earlier studies.

One possible explanation of the relative independence of neural and hormonal factors is that regions controlling the endocrine cycle are too widely distributed to be entirely destroyed by small lesions, and thus surviving tissue can maintain the function. Disruption of any considerable part of the mechanism involved in the complex act of mating, however, may well abolish the capacity for the performance. Thus control of the gonadotrophins may be topographically more diffuse in the hypothalamus than the related control of sexual activity; or the latter may require greater integrity of the system.

That there is a system in the female rat which opposes or inhibits receptivity is apparent from the data for animals with posterior hypothalamic lesions and probably from the data for animals with anterior hypothalamic lesions as well. These influences may well be related to others originating in more remote areas, as reported for the amygdala (*8*) and the cortex (*9*).

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References and Notes

1. P. Bard, *Research Publs. Assoc. Research Nervous Mental Disease* 20, 551 (1940).
2. J. M. Brookhart, F. L. Dey, S. W. Ranson, *Endocrinology* 28, 561 (1941).
3. J. M. Brookhart and F. L. Dey, *Am. J. Physiol.* 133, 551 (1941).
4. M. A. Greer, *Endocrinology* 53, 380 (1953).
5. C. M. Rogers, unpublished Ph.D. Thesis, Yale Univ., 1954.
6. This study was supported by U.S. Public Health Service grant No. M 1379 to Dr. R. W. Gerard. We gratefully acknowledge Dr. Gerard's support.
7. Diethylstilbestrol (500 μg) followed 48 hours later by progesterone (1.0 mg). Both were dissolved in sesame oil and administered subcutaneously.
8. L. Schreiner and A. Kling, *J. Neurophysiol.* 16, 643 (1953).
9. F. A. Beach, *J. Comp. Psychol.* 36, 169 (1943).

25 June 1958

Meetings

Chicago Academy of Sciences

It is significant of the rapid growth of our country that the Chicago Academy of Sciences, at the time of its founding in 1857, should have been known as "the first museum of the West." It is strange, indeed, to reflect that only 100 years ago Chicago was a sprawling pioneer community and that the academy was the first scholarly institution on the scene. Washington's Smithsonian had been founded only 11 years earlier, and through the years a traditional bond has existed between the two. Robert Kennicott, first director of the academy, was a young protégé of Spencer Fullerton Baird, assistant secretary of the Smithsonian in those days. It was the young Kennicott whose scientific reports on Russian Alaska, as leader of the Overland Telegraph Expedition, made the United States aware of the value of this vast territory. When the project to link Europe to North America via Bering Strait was terminated by the successful laying of the Atlantic cable, the scientific results of the Kennicott expeditions were the only tangible results of the giant undertaking. But they influenced our Government to purchase Alaska.

Early sites of the academy were twice destroyed by fire, the last time by the great Chicago fire of 1871. The present building in Lincoln Park was built in 1893 at a cost of $100,000, through the generosity of Matthew Laflin, who contributed $75,000, and the commissioners of Lincoln Park, who contributed $25,000. The academy has received major bequests from several others—$100,000 from W. Moses Wilner, $140,225 from Melissa Dickinson, $150,000 from Albert Dickinson, and $26,843 from Elsie S. Sandquist.

Founded for the "increase and diffusion of scientific knowledge," the academy has steadfastly pursued this goal. But science has its vogues, even as the world of fashion. In 1857 science was acquisitive. It was a time for discovery and classification of animals and plants, and in the early academy *Transactions* such work was published and broadcast to the scientific world. So, too, in its present *Bulletin, Special Publications,* and *Natural History Miscellanea,* the academy has ranged the whole wide field of science to continue the "increase and diffusion" of such knowledge. In an old institution like this you may read history off the library shelves or herbarium sheets. Here is a copy of Dana's *System of Mineralogy,* published in 1868; here a collection of plants made west of the 100th meridian by Palmer and Wolf in 1868.

Now the vogue is changing. The need for taxonomy is still as acute as ever in entomology and invertebrate classification but less urgent for higher vertebrates. There is time to investigate the biological interrelationships of animals and plants in studies of ecology and parasitology. Joseph Camin, staff acarologist, has a three-year grant from the National Institutes of Health to study mite-borne diseases and the genetics of the ability of mites to transmit blood diseases of vertebrates. The academy director concerns himself with bird physiology and the influence of the ice age on bird speciation and present migration routes.

But the academy feels most strongly its responsibility to diffuse knowledge to the public. At a time when science education is actually unpopular in the schools and scientists are regarded variously as unfeeling ascetics and dangerous crackpots, our role should be to correct misconceptions. Obviously, students come by such ideas via their teachers, and the need for good science teachers is therefore as great as that for well-informed students. Badly needed, too, is a respect for scholarly accomplishment to replace the present passion for mediocrity among students and even professional men. To

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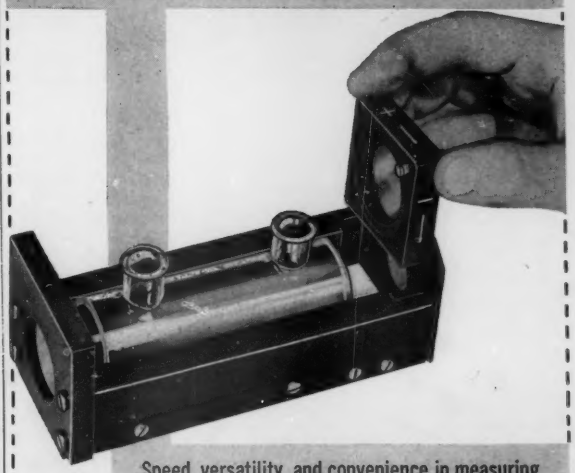

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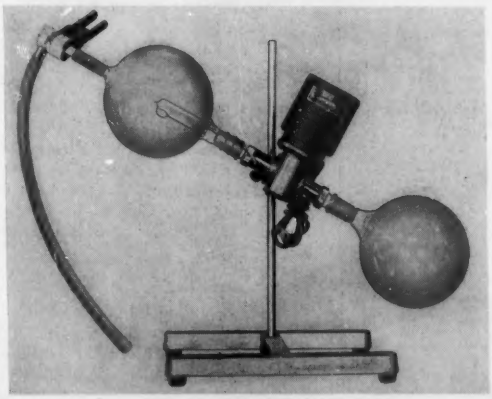

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The present officers of the Chicago Academy of Sciences, elected at the 101st annual meeting, which was held 16 Apr. 1958, are as follows: President, Leslie B. Arey, professor of anatomy, Northwestern University Medical School; secretary, Richard A. Edgren, Division of Biological Research, G. D. Searle and Company; director, William J. Beecher.

WILLIAM J. BEECHER
Chicago Academy of Sciences, Chicago, Illinois

Forthcoming Events

January

23–24. Reproductive Physiology and Protein Nutrition, 15th annual conf. on protein metabolism, New Brunswick, N.J. (J. H. Leathem, Rutgers Univ., New Brunswick, N.J.)

24–29. American Acad. of Orthopedic Surgeons, Chicago, Ill. (C. L. Compere, 720 N. Michigan Ave., Chicago, Ill.)

26–29. American Meterological Soc., New York, N.Y. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

26–29. American Soc. of Heating and Air Conditioning Engineers, 65th annual, Philadelphia, Pa. (W. M. Vidulich, ASHACE, 62 Worth St., New York 13.)

26–29. Institute of the Aeronautical Sciences, 27th annual, New York, N.Y. (IAS, 2 E. 64 St., New York 21.)

26–30. Writing and Publication in Industry, conf. and workshops, Brooklyn 1, N.Y. (T. L. Donahue, Writing and Publication Conf., Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn 1.)

27–30. Society of Plastics Engineers, Inc., 15th annual tech. conf., New York, N.Y. (L. A. Bernhard, SPE, 65 Prospect St., Stamford, Conn.)

28–29. Nuclear Fuel Elements, 1st intern. symp., New York, N.Y. (H. H. Hausner, 1st intern. Symp. on Nuclear Fuel Elements, 730 Fifth Ave., New York 19.)

28–31. American Physical Soc., annual, New York, N.Y. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

29–31. Western Soc. for Clinical Research, 12th annual, Carmel-by-the-Sea, Calif. (W. N. Valentine, Office of the Secretary, Univ. of California Medical Center, Department of Medicine, Los Angeles 24.)

February

1–6. American Inst. of Electrical Engineers, winter general, New York, N.Y. (N. S. Hibshman, 33 W. 39 St., New York 18.)

2–6. American Soc. for Testing Materials (committee week), Pittsburgh, Pa. (ASTM, 1916 Race St., Philadelphia 3).

3–5. Reinforced Plastics Conf., 14th, Chicago, Ill. (Society of Plastics Industry, Inc., 250 Park Ave., New York 17.)

6–7. American College of Radiology, Chicago, Ill. (W. C. Stronach, 20 N. Wacker Dr., Chicago 6.)

9–11. American Acad. of Allergy, Chicago, Ill. (B. Rose, Royal Victoria Hospital, Montreal, P.Q., Canada.)

9–11. Nature of Coal, symp., Bihar, India. (Director, Central Fuel Research Inst., P. O. Fuel Research Inst., Dhanbad District, Bihar.)

11–13. American Acad. of Occupational Medicine, Boston, Mass. (L. Blaney, 1608 Walnut St., Philadelphia, Pa.)

12–13. Solid State Circuits Conf., Philadelphia, Pa. (A. B. Stern, General Electric Co., Bldg. 3, Syracuse, N.Y.)

14. Short Range Navigation Aids, Montreal, Canada. (Intern. Civil Aviation Organization, Maison de l'aviation internationale, Montreal.)

15–19. American Inst. of Mining, Metallurgical, and Petroleum Engineers, annual, San Francisco, Calif. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

16–19. Problems in Field Studies in Mental Disorders, intern. work conf., New York, N.Y. (J. Zubin, American Psychopathological Assoc., 722 W. 168 St., New York 32.)

(See issue of 19 December for comprehensive list)

A checklist of CB translations of 1958 Soviet scientific journals . . .

Biology and Medicine

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√ JOURNAL OF GENERAL CHEMISTRY (*Zhurnal Obshchei Khimii*) 12 issues, $90.00*
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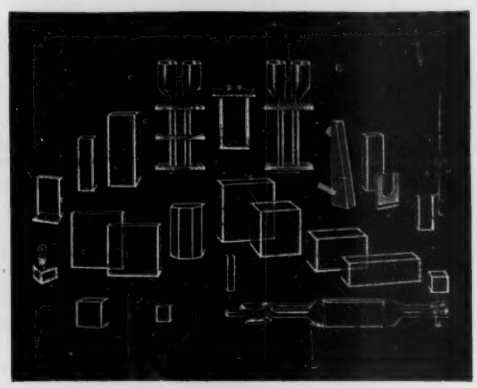

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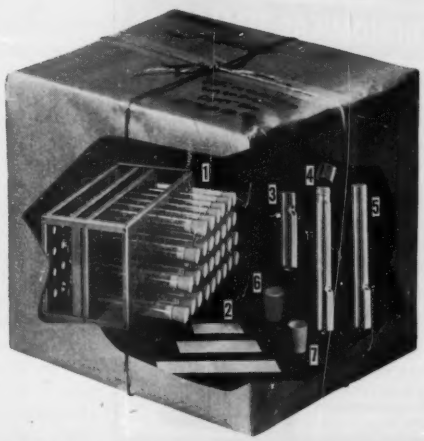

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Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 1634.*

■ FUNCTION GENERATOR employs conventional diode-breakpoint circuitry, but setup is accomplished by inserting a punched card into the front of the function generator and closing an actuating door over the card. Twenty segments are provided. The breakpoints are set with respect to the forcing function by means of plug-in resistor assemblies. The slope of the curve at a particular breakpoint is adjusted by the binary-coded information punched into the card. Repeatability of settings is ± 0.02 percent. (Mid Century Instrument Corp., Dept. 534)

■ ELECTRONIC SWITCH accepts four independent signals and sequentially converts them to a single input to an oscilloscope. Switching rate is 500 kcy/sec, permitting 2 μsec per switch position. The unit consists of a free-running oscillator, an electronic counter, a diode gating matrix, and level-mixing cathode followers. (Newton Co., Dept. 544)

■ PRESSURE TRANSDUCERS of the diaphragm-variable reluctance type are offered with pressure ranges from 0 to 5 through 0 to 3000 lb/in.² and from ± 2 through ± 300 lb/in.². Sensitivity to shock and vibration is 0.001 to 0.03 percent/grav. Rise time is 75 to 150 μsec. (Ultradyne Inc., Dept. 545)

■ RECORDER AMPLIFIER is designed to drive high-frequency galvanometers. The unit is a dual-channel, chopper-stabilized amplifier and is capable of delivering up to 200 ma at 0 to ± 10 v d-c or a-c (peak) in each channel. Gain is adjustable from 0.1 to 2.0 (Data Control Systems Inc., Dept. 546)

■ SCINTILLATION WELL COUNTER provides 2 in. of lead shielding in a sectionalized unit 7 in. in diameter by 12¼ in. high. The scintillation probe is equipped with a 2- by 2-in. NaI crystal and has a well for samples 1 in. in diameter. Removal of the shield plug elevates the probe unit to the top of the shield for sample changing. (Nuclear-Electronics Corp., Dept. 548)

± RADIATION DETECTOR combines a gamma radiation detector with a transistorized radio for civil defense applications. Range of detection is background to 100 r/hr. An ionization chamber is used as the detector. Power is provided by a mercury battery. Indication is provided by a logarithmic-scale meter. (Riggs Nucleonics Corp., Dept. 552)

■ FLOWMETERS of turbine type measure gas flow from 0.03 to 30,000 ft³/min. Each model of the series measures over a 10-to-1 range. Accuracy is ± 0.5 percent of reading. The smaller meters in the series use magnets imbedded in the spinning rotor to induce pulses in an external pick-up coil. Larger sizes use reluctance-type pick-ups. In either type the output drives totalizers, counters, rate indicators, recorders, and control devices. (Potter Aeronautical Corp., Dept. 554)

■ CHROMATOGRAPH CONVERSION KIT permits existing chromatographic instruments to be used in catalytic-combustion detection. The kit consists of a detector assembly, a bridge circuit, and a power supply. The detector assembly contains two catalytic combustion cells, one a reference cell. The cell block is made of stainless steel. All ports are ⅛-in. pipe tap. Output from the bridge is suitable for input to standard potentiometer-type recorders with 5- to 10-mm range and 1- to 2.5-sec full-scale speed. (Davis Emergency Equipment Co. and Greenbrier Instruments, Dept. 560)

■ PHOTOMETER is direct reading in density from 0 to 4. Accuracy is ± 0.02 density units over the entire range. The multiplier-phototube probe of the instrument is designed for use as a hand-held detector. Two attachments, a reflection head and a transmission attachment, are available. (Macbeth Corporation, Dept. 551)

■ CONTROLLED-AIR SOURCE provides air flows from 1 to 18 ft³/min over a range of pressures from near vacuum to 20 lb/in². Wet-bulb temperatures ranging from 0° to 100°F and dry-bulb temperatures from 0° to 150° are controlled to ± 1°F. Operation is on 115 v a-c. (Mira Corporation, Dept. 553)

■ ENVIRONMENTAL TEST CHAMBER permits testing in the temperature range − 100° to + 800°F. Temperature control is accurate within ± 2°F. Interior working dimensions are 18 by 18 by 18 in. Insulation is 7-in. thick Fiberglas. A multipane window is optional. (Associated Testing Laboratories, Dept. 556)

■ FLAW DETECTOR locates defects in conductive materials. The instrument consists of an indicating unit, and an inspection probe. The latter is part of an antiresonant bridge. As the probe passes over a crack or metallurgical difference, an unbalance occurs which is indicated by deflection of a meter. Compensation is provided to permit testing of semirough surfaces so that oxide layers or pits up to a thickness of 0.02 in. will not affect accuracy. (Magnaflux Corporation, Dept. 538)

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National Bureau of Standards

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(a) **Medical Director**; duties consist of directing clinical investigations relating to product development; preferably physician, with several years' experience in the pharmaceutical field; Chicago; $18,000. (b) **Chemist**; supervisory position in chemistry section of research department, large industrial company; college town, Pennsylvania; Ph.D. preferred. (c) **Ph.D.'s** in biochemistry and pharmacology to work in divisions of biochemistry, physiology and pharmacology as second man; administrative experience required; $14,000; East. (d) **Physician** to serve as director of research, rehabilitation program of well-known foundation; New England. S12-4 Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

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Prospective applicants should write for further information to Professor H. Kleerekoper, Chairman, Department of Biology, Hamilton College, McMaster University, Hamilton, Ontario, Canada. Application forms both for scholarships and graduate study are obtainable from the Dean of Graduate Studies and must be returned to him normally by **1 March 1959**, accompanied by university transcript and letters of recommendation from two professors. 12/26; 1/2

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(*Continued on page 1634*)

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- **DESIGNED FOR BENCH OPERATION**

Style: Vertical strip chart recorder, designed for laboratory bench operation. Assembly of three individual, separable, and self contained units; viz., control panel assembly, amplifier and power supply chassis, and chart and pen drive chassis unit.

Automatic null balancing potentiometric system with standard cell standardization by panel control, conventional chopper-amplifier method with special Sargent high gain amplifier and high stability Sargent bridge power supply using combined or alternate dry cells and mercury cells. Use of the latter obviates need for standardization over very long periods.

Ranges: Multiple full scale ranges selected by panel range switch as follows: 1.25, 2.5, 5, 12.5, 25, 50, 125, 250, 500, 1250, 2500. All ranges are made direct reading as full scale deflection in millivolts, milliamperes, or microamperes by use of an associated units selector switch. All 33 scales provide true potentiometric measurement. An additional series of the same eleven ranges in terms of volts is provided by an additional selector switch position, this series using a divider input with an impedance of one megohm.

True potentiometric measurements are thus provided to a maximum of 2.5 volts, higher voltages only being measured through a divider.

Accuracy: 0.1% or 20 microvolts, whichever is greater.

Chart: Width, 250 mm; length, 120 feet. Ruling rational with all ranges on a decimal basis. Indexed for reference. Graduated steel scale provides for any necessary correction of calibration. Two-position writing plate, 15° or 40° from vertical.

Chart Drive: Forward drive recording, reverse drive recording, magnetic brake eliminating coasting when stopped and free clutch position with separate provision for rapid non-synchronous drive.

Recording speeds of ⅓, ½, 1, 1½, 2, 2⅔, 4, 8, and 12 inches per minute, selected by interchange of two gears on end of chassis.

Free clutch or neutral drive at the rate of approximately 20 feet per minute in either direction for rapid scanning of recorded information, chart reroll, or chart positioning.

Recording either by automatic take-up on roll or with free end chart and tear off.

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Pen Speed: 1 second full scale. Other speeds can be provided on special order with change of motors.

Bridge: Special Sargent specification. Provision for coupled transmitting potentiometer for output to integrating circuits, etc.

Damping: Dynamics controlled with single panel knob adjustment of amplifier gain.

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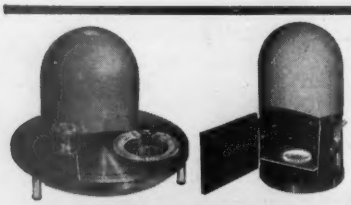

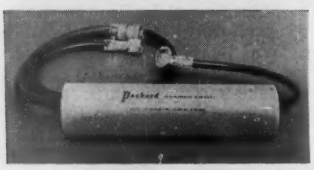

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